CMS NOTES de la SMC

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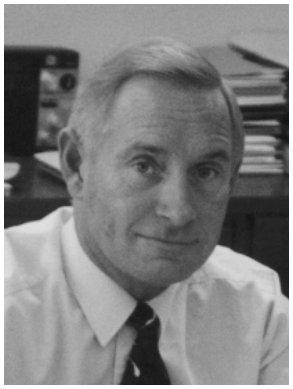
FROM THE EXECUTIVE DIRECTOR'S DESK



Graham Wright

Make Math Count

When this year's fund raising campaign *Make Math Count* was developed, it was hoped to obtain a higher level of support and recognition for the Society's research and educational activities. Although there have been some disappointments, there have been a number of successes.

The support received from the host universities and the three research institutes has enabled us to expand the programmes for our semi-annual meetings and, consequently, the number of participants has increased significantly. This very positive trend should continue for our future meetings.

The 1999 Winter Meeting in Montreal not only features an excellent scientific programme but will also include the first CMS Job Fair. Information on this Job fair is included in this issue of the CMS NOTES. It is hoped to continue this important cooperative effort between the host university, the research institutes, the private sector and the Society and for the Job Fairs to take place at each CMS semi-annual meeting. I am pleased to report that the sites for future meetings are confirmed to 2004 and I am confident that each meeting director will continue to provide an excellent scientific programme.

In the September NOTES, Daryl Tingley reported on the CMS Awards Banquet that took place in June, the support received from corporations, governments and by the CMS membership in our competition activities, and that it was nice to see mathematical talent getting recognition from the media. The increased coverage and interest in our various educational activities is very encouraging.

I am particularly encouraged with the interest and support for the CMS programme of math camps. Although Summer and Winter IMO Training Camps have taken place for a number of years, the CMS wanted to develop a programme of regional and national math camps that would have a wider scope and broader appeal. The regional camps are mathematics enrichment camps primarily for Canadian students in grades 8 through 10 while the national camp is mainly for younger Canadian students with at least two

(see MATH–page 14)

CMS NOTES
NOTES DE LA SMC

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EDITORIAL

Peter Fillmore

In this issue of the NOTES we are pleased to bring you printed versions of two of the plenary lectures at the St. John's meeting: Ed Barbeau's "Men as trees walking" and John Friedlander's Jeffery-Williams lecture "Prime values of polynomials". Both talks were enthusiastically received and we are glad to make them available for further study. We hope to do more of this in future and would welcome reader reaction.

The conference season is approaching and many of us have begun considering our choices. Here is a brief selection. The upcoming CMS meeting in Montreal is full of interest, preceded immediately by the CRM's 30th anniversary celebration and followed by the first CMS Job Fair. Beyond that we can choose from a number of meetings that include special World Mathematical Year 2000 features.

In January we have the Joint Mathematics Meetings in Washington DC. A united congress of Quebec mathematical organizations and groups takes place at Laval in May, and in June follows the MATH 2000 meeting at McMaster, organized by the CMS and a number of other Canadian mathematically-oriented societies. Just prior to that is the two-day Symposium on the Legacy of John Charles Fields, at the Fields Institute in Toronto. July brings the 3rd European Congress of Mathematicians (Barcelona) and ICMI-9 (Tokyo), and August the AMS meeting "Mathematical Challenges of the 21st Century" in Los Angeles.

More information about these events can be found in our calendar section, as well as at the WMY2000 website <http://wmy200.math.jussieu.fr>. This list, admittedly of just a few highlights, is surely an impressive testament to the vitality of the global mathematical community as we approach the new millenium. Why not start planning your participation now?

Nous sommes heureux de vous présenter dans ce numéro de NOTES deux des conférences plénières de la réunion de St-John's, celle d'Ed Barbeau et de John Friedlander ("Men as trees walking" et "Prime values of polynomials"). Elles furent toutes deux accueillies avec beaucoup d'enthousiasme et c'est avec plaisir que nous vous donnons l'occasion ici de les relire et de les approfondir. Nous espérons renouveler cette expérience dans l'avenir et accueillerions avec plaisir vos commentaires à ce propos.

La période intensive des conférences approche à grands pas et plusieurs se penchent sur les choix à faire. Nous vous en présentons ici un bref aperçu. La prochaine réunion de la SMC à Montréal s'annonce fort intéressante. Elle se trouve précédée de la célébration du trentième anniversaire du CRM et suivie du premier Carrefour emploi de la SMC. Entre ces deux événements, il y aura un vaste choix de réunions qui porteront sur l'an 2000, année internationale des mathématiques.

En janvier prochain se tiendront les réunions mathématiques communes à Washington, DC. Un congrès réunissant les organismes et groupes mathématiques du Québec aura lieu à l'Université Laval, en mai; il est suivi, en juin, de la rencontre MATH 2000, à McMaster, organisée par la SMC et d'autres sociétés à teneur mathématique du Canada. Tout juste auparavant, il y a le Symposium sur l'héritage

de John Charles Fields, au Fields Institute de Toronto. En juillet, ce sera le troisième Congrès européen de mathématiques, à Barcelone et en août, à Los Angeles, aura lieu la réunion de l'AMS sous le thème "Les défis mathématiques du 21e siècle".

On peut trouver tous les renseignements sur ces activités dans la section Calendrier ainsi qu'au site Web de l'an 2000, année internationale des mathématiques, à l'adresse http://wmy200.jussieu.fr. Bien que la liste ci-dessus soit fort partielle, elle témoigne de façon convaincante de la vitalité de la communauté mathématique internationale, au seuil du nouveau millénaire. Ouvrez vite vos agendas et commencez dès maintenant à planifier votre participation!

Men as Trees Walking

Ed Barbeau, University of Toronto

This article is based on a plenary talk given on May 29, 1999 at the Summer Meeting of the Canadian Mathematical Society in St. John's, NF.

Ed Barbeau

"Men as trees walking" – this was the phrase that came into my mind as I examined the draft *Principles and Standards of School Mathematics* **(1)** recently issued by the National Council of Teachers of Mathematics. The phrase is from the Bible (Mark 8:22-26), where a curious miracle is described. A blind man touched by Christ could at first see only "men as trees walking" and required a second touch in order to see clearly.

One has the same feeling about the *Principles and Standards*; while it is generally praiseworthy, it is hard to bring the document into a clear focus. It contains a mixture of recommendations about topics, processes, teaching styles and general philosophy, but, as a lecturer of first-year university students, I did not get a clear sense of what I would be able to count on from the students in front of me. It seems that there is such a plethora of ideas put forward that perhaps a second healing touch is needed to tease out clearly the main threads.

The central issue became clear to me one evening as I watched Rob Buckman on TV Ontario present a documentary on alternative medicine. Many people were alienated from traditional medicine which they found too reductionist and narrowly focussed. Whatever the specifics, alternative medical regimes were attractive because they were holistic, proceeded from a broader worldview and significantly involved the patient in the diagnosis and choice of treatment. Cases that might seem identical to a traditional doctor might receive quite different treatments for patients in different environments. Surely something like this is behind the pressure for reform in education. Teachers and students are reacting against a curriculum which seems to be reduced to a list of topics and processes, against an imposed canon robbing students and teachers of their autonomy. Whatever the details might be, we want students to be intimately involved in an educational process that cares about who they are and what characteristics they bring to the mathematics class.

But the charge that traditional education (as traditional medicine) has consistently lacked the human touch is far too stereotypical; it has resulted in a number of ghosts that have haunted recent educational reform. Let us raise a few of them.

Ghost 1: failure, streaming, elitism. There is no doubt that school was a brutal experience for many students in the past, but the fact remains that success in mathematics depends on a certain level of ability and application. To deny students the opportunity to fail is also to deny them the opportunity to enjoy success. This is not a call to ignore students who are floundering, but rather to create conditions that do not neglect the imperatives of learning mathematics and the possibility for achievement, but do provide support in which these might be realized and students can move on in confidence. Many students now are uncertain about what they can do or should know; even good students are denied the chance to demonstrate what they are capable of. While there is much that can be done to make mathematics more generally accessible, it needs to be recognized that the subject is often difficult and beyond the ability or interest of some segment of the population.

Ghost 2: the syllabus, list of prescribed topics, facts and procedures. The charge here is that having a *list* is too confining and leads to an emaciated mathematics that is reduced to a disembodied set of facts and routines. It is not clear why this should *necessarily* be the case. In fact, the criticism seems to be misplaced; it should be directed at matters of design. In the hands of a teacher familiar with mathematics, the syllabus can serve as a set of markers and goals that frame what will happen in the class. An uncertain or ignorant teacher will hold to the list without any regard to connections and deeper understanding.

Ghost 3: drill, rote learning and memorization. Memorization was an important part of traditional education, and many cultures put a great deal of emphasis on what children should *remember*. Children seem to have good memories, and it seems foolish not to take advantage of this. But they need to be taught to evaluate what is worth memorizing, how mastery can be reached and how they can exploit the coherence of mathematics to leverage their knowledge of a few facts into fluency over a larger domain. The most able children can do this naturally; others need to have the issue explicitly addressed, so there is an underlying equity issue involved here for students without natural talent.

Ghost 4: arithmetic. This is a word that seems to have fallen upon hard times in the curriculum stakes. But it is through arithmetic that most ordinary citizens engage the connection between mathematics and the world, and lack of numeracy can present a severe handicap. Arithmetic has come to symbolize mindless memorization and manipulation. We need to detach it from this calumny and exalt it to the level of mathematical richness that it deserves.

Ghost 5: paper-and-pencil algorithms. This also is tarred with the brush of drudgery, and the advent of modern technology has provided detractors of traditional calculation with a pretext for summarily discarding it. The issue is really how traditional arithmetic should be handled in a modern curriculum. Perhaps we need to see them more as an additional means of accustoming students to working with figures or as examples of algorithms. Long division seems to be particularly suitable for indicating how one can move from the idea of tallying a continued subtraction to a mechanical algorithm which is fast and accurate; one can point out that it was a human invention and replaced a method that was decidedly inferior (the "scratch method"). What has changed is that the importance of paper-and-pencil methods as a practical technique is reduced and we now have alternatives for reaching children encountering difficulties.

Ghost 6: word problems. Traditional word problems are criticized as being artificial, but one can argue that this is precisely the point of most word problems. They provide a toy situation in which certain points about interpretation, and formulation can be made. The question again is not whether we should retain word problems, but how appropriate they are to the situation and how we plan to move beyond them.

Ghost 7: authoritarianism. This ghost has two manifestations, depending on whether you are referring to the teacher, who, we are told, should be the "guide on the side" rather than the "sage on the stage", or to the subject itself in which pupils are oppressed by the tyranny of "one right answer". Without disputing the advantages of the more open and friendly classrooms that modern students enjoy, it remains the case that a teacher's effectiveness depends on what she knows and that sometimes students need to submerge their egos and pay attention to what she has to say. In the same way, it seems mischievous to deny the power of mathematical certainty, especially given the diversity of the ways in which one might think about concepts and approach problems. (One feels that the work of Gödel and Lakatos, however lauded by serious mathematicians, have had a particularly pernicious effect on some mathematics educators seduced by the vamps of relativism.) There are many ways to encourage the individuality of pupils without permitting them to believe that black is white.

All of these Ghosts are the traces of essential components of mathematical education in the past which had better be part of the future as well. Children are going to either succeed or fail at any worthwhile task, and the question is how humanely the failure is handled and whether pupils are held back or advanced for frivolous reasons. Mathematics is an hierarchical subject and we need to spell out what students need to master at each stage; the issue of the syllabus is one of design and focus. We cannot deny the need for practice; the question is whether the student has the strategies and perspective to learn and memorize efficiently and effectively. Arithmetic and the standard algorithms are as important as ever; what we need is to be sure that they are put into the proper context and conceptual framework.

These Ghosts are accompanied by a number of Sirens that drive a lot of educational reform. Like the ghosts, the sirens also speak to important aspects of the mathematics education. Here are some of them.

Siren 1: problem solving and investigation. This siren calls us away from the ghost of drill, of dry and unilluminating exercises. There is nothing wrong in wanting our children to solve problems and explore mathematical situations, but we can run into serious distortions if we do not take the trouble to ground them mathematically and psychologically.

Any problem we present to children should be carefully analyzed for its mathematical content and appropriateness to the maturity of the pupils. Strategic decisions need to be made as to what mathematics has to be presented beforehand as background and what can be brought out in the analysis of the problem. Let me give an example that I have used with students and prospective teachers.

Let ABCD be a unit square and let E and F be the respective midpoints of sides BC and CD. The three line segments AE, AF and BF partition the square into five regions. It is required to determine the area of each region.

There is actually quite a lot in this. At what point should this example be introduced, before or after the pupils see the area formula (half-base-times-height) for triangles? This will govern how they might approach the problem. If the students are to try a structural rather than a formulaic approach, they

might need at least implicit understanding of isometries and might need to understand that areas of nonoverlapping sets add, that areas are invariant under rigid transformations and that they vary as the square of the factor of a dilatation. Should some of this be discussed ahead of time, or can it emerge as the problem is covered? If the students exploit the similarity of the two subtriangles of ABE, they may need to know that AE is perpendicular to BF; what tools can they be expected to deploy? Will students who assign letters to the five regions have the necessary algebraic understanding to proceed, or is this a nice vehicle to introduce them to this approach? Finally, will the pupils be able to negotiate the fractions? Are the fractions appropriately expressed in vulgar or in decimal form; why? When we take all of this into consideration, this example could take quite a bit of time to do properly - has this been anticipated by the teacher?

The problem-solving approach to the curriculum has a great deal to be said for it, but it does require imagination by the teacher to envisage what might happen and, importantly, what can possibly go wrong. It is risky, and we should be sure that teachers are equipped to accept the risks.

Siren 2: relevance; real-life. Mathematics was seen to be alienating because of the artificiality of what we were asking students to do. We should make reference to the daily lives of the pupils and concern ourselves with what they will need to succeed in their later careers. But what passes for relevance often raises the question "for whom?". It seems that children often have the phony relevance of a tedious arithmetic problem dressed up with clowns and cookies or are brought into the world of adult concerns in the name of relevance. *Play* is a part of the world of a child, and the unadulterated world of mathematics gives lots of opportunity for this. I have never been aware that some nice number, geometric, topological or combinatorial novelties have been beyond the pale for the children I have had the pleasure of presenting mathematics to.

Siren 3: patterns. No mathematician can gainsay the important of a sense of structure in doing mathematics, and the ability to recognize pattern is an important part of this. What has been forgotten in a lot of modern educational reform is that the power of patterning is seen in its use in analyzing and generalizing mathematical situations. Much of what passes for patterning is a kind of teacher "guess-my-rule" game and rather ad hoc examples. There is no excuse for this. It is hard to progress through the curriculum without finding natural opportunities to exploit patterns, and teachers need to be alert to this and make them explicit to their pupils at the right time. One aspect that seems to be neglected is giving the students the mathematical voice to describe and analyze patterns.

Siren 4: data analysis. We do not have to look very far to realize how much of our daily lives is governed by a flood of data of one sort or another. So there is certainly a duty to help pupils become number-wise and to interpret what they read astutely. But the danger is that we do not just cover a lot of canned techniques and introduce jargon, which may in some cases stand in the way of good discussion and analysis.

Siren 5: technology. First, let me agree that through modern technology we are undergoing changes in our lives that are at least as profound as those induced by the invention of the printing press and the Industrial Revolution. But any revolution, no matter how pervasive, is not completely disjoint from the past. Many of the issues raised by technology are old ones, and the charge of misuse and mindlessness can be and has been leveled against Arabic numeration, algebraic symbolism, logarithms, slide rules, mechanical adding machines and numerical algorithms of all types whether executed on paper or on a bench with pebbles. Certainly, the modern computer has greatly expanded both the range of the mathematics we *can* do as well as the mathematics we *want to* do; our curriculum should reflect this. But we do not need idolatry. Technology is *there* part of our environment, as are books and pens, and a general purpose of education is to produce students who can understand and work within their environment. There are core mathematical issues that are independent of technology, but can be greatly informed by our use of technology - it is in this spirit that we should embrace the use of calculators and computers in our classrooms.

All of the sirens speak to important aspects of the modern mathematics curriculum, but they all involve subtle issues and bring the risk of being trivialized. The big question is whether we will have teachers in front of our children who will handle the issues in a sensitive, moderate and intelligent way.

In designing a curriculum, we need to keep both the Ghosts and Sirens in mind, for each of them not only speak to important goals but also carry a warning of distortion and counterproductivity. There are a number of factors that we need to be cognizant of.

1. For a body of mathematics, I believe that there are three stages that a learner must pass through, *initiation*, *formalization* and *consolidation*. In the stage of initiation, the learner encounters the ideas in a somewhat haphazard way, feeling her way about, exploring; there has to be some motivation, some reason that the person is interested in the material at hand. At the formalization stage, the ideas are drawn together and organized; at this point, the pupil should learn proper concepts, processes and conventions. There may indeed be a lot of artificiality; the payoff should be a growth in the knowledge and mathematical power of the learner. In the consolidation stage, the learner reflects upon what has gone before, contextualizing it, detecting relationships and connecting it to other material. It may be only here that the

learner truly appreciates the reasons for what she has been taught before. Traditional education has emphasized the second of these stages while modern practice seems to focus on the first and third without the buttress of the second stage. A good curriculum allows for all three stages to occur. The first signifies to the pupil that the subject matter *could* belong to them, the second provides the tools to *allow* it to belong to them and the third ensures that it *does* belong to them.

2. Have a strong focus and a slender core for each course in the curriculum. Make sure that context is established, the purpose of the material becomes clear, there is enough depth to support its assimilation and allow students develop the necessary skills and understanding to proceed.

3. Have one or two attainable goals for each year; plan to achieve them and *move on*. This means that the sort of sterile spiralling that now occurs in schooling should cease, but does not preclude returning to previous material to inform and consolidate it.

4. Have enforceable entry requirements for secondary and tertiary courses. No teacher should be asked to deal with a student who does not have reasonable prerequisites for the material to be studied. There is an important pedagogical purpose in requiring students to review and organize in their minds the work of several months or a year; it is this process that makes purposeful curriculum progress possible.

5. Change pace. The diversity of the mathematical enterprise should be reflected in our curriculum, whether with respect to subject matter, level of discourse or application. There are many ways in which people can think about or do mathematics. Therefore, we need space to help students find their mathematical voices and texture their ways of thinking about and doing mathematics.

6. Orchestrate the material. Increase the level of complexity judiciously, make sure that foundational material is covered and the student is psychologically prepared for what is to follow. We need to analyze in much more detail what students are asked to do; this is where members of the University community can be particularly helpful. Too often problems are thrown at pupils with little appreciation of what needs to be in place to embark upon them. A sound curriculum needs both exercises and problems of many different intensities.

This is one area in which the *Principles and Standards* seems to be particularly weak. There are a number of examples thrown in, that upon closer analysis seem to involve a great deal that the proponent might not be aware of. On page 92 is a set of instructions for constructing a golden rectangle. This seems as though it might be pretty heavy sledding for a typical student, and any teacher who embarks on this without careful thought is wading into a treacherous swamp. Why should pupils be interested in a golden section, or in ways of constructing such a thing? Will most pupils muster the necessary level of concentration to negotiate the ten-stage unmotivated set of instructions and understand why it works? This example is meant to illustrate the connectedness of mathematics, but it seems to me to require such a level of maturity and mastery of some basic algebra that it could easily spin out of control in the hands of any but the most adept teacher.

7. Meet different needs. Whatever reason we can give for teaching anything at all applies to mathematics. Some mathematics is taught so that students will be able to accept the privileges and responsibilities of citizenship, some to situate them in the rich culture that they are entitled to inherit, some to provide recreation and additional options towards a full and rewarding life, and some for professional preparation. These needs can sometimes be met by the same piece of mathematics, but all should inform the curriculum that we set.

8. Foster sound practice and mental attitudes. How well students perform in mathematics seems to depend on the worldview that they bring. In designing a curriculum, we should encourage an attitude of mind that involves the following:

(a) Awareness of structure; appreciation and exploitation of symmetry;
(b) Flow of ideas, analysis and reasoning;
(c) Corroborative quality of mathematics; inner consistency;
(d) Shifting of perspective;
(e) Checking and monitoring one's work;
(f) Organizing and polishing one's work;
(g) Mathematical register; expressing ideas appropriately; the place of heuristic and formalism;
(h) Sense of context;
(i) Attainment of power through understanding, reasoning and technical facility;
(j) Visualization; appropriate imaging;
(k) Appreciation of symbolic representation: numeration, algebra, diagrams;
(l) Making distinctions: classification, equivalence, isomorphism, congruence;
(m) Grasping the interplay between concrete and abstract; progression to higher order structures that in turn become "concrete".

9. Finally, we come to the subject matter itself. The centrality of arithmetic and algebra must be affirmed. No student can succeed at the secondary level without a good grasp of arithmetic, nor succeed at the tertiary level without a good algebraic grounding. But these are not all. Geometry and combinatorics are also indispensible. While students should see how mathematics can be applied in different areas, it is not clear to me that this should necessarily occur in the mathematics class. Science, shop, civics, geography and music are areas in which important mathematical concepts can be conveyed in an appropriate and powerful setting. And we should not forget how

many important mathematical concepts and processes underly some recreations and puzzles. In fact, if the elementary and secondary curricula are well-designed, one could devote the middle school years largely to recreational and cultural issues as a way of consolidating what should have been learned at the elementary level and preparing the ground for a more sophisticated high school program in which symbolism, algorithm, analysis and reasoning have important roles.

I would like to close with two courses that might be given at the levels of grades 9 and 10. The first is designed to give a systematic introduction to algebra and the second to geometry. It is assumed that students have gone through an initiation stage in both areas, that they have some familiarity with formulae and the use of letters to represent numerical quantities, and that they have had the opportunity to play around with geometric objects either through tactile or computer models. While technology is not explicitly mentioned in either syllabus, it is understood that it can play a large and appropriate role. These syllabi would be accompanied by resources for the teacher that lay out alternative approaches as well as useful exercises, problems and investigations, and that make explicit the pedagogical and mathematical goals that are brought to light through the material.

Course 1: Linear and quadratic functions

1. The linear equation $ax = b$. Problems that lead to an equation of this form.

2. The equation of the straight line; slope; various forms.

3. The solution of a system of two linear equations in two unknowns using numerical, algebraic and graphical techniques. Consistency of two linear equations.

4. Factoring difference of squares.

5. The quadratic: factoring over reals and integers, completion of the square, quadratic formula, discriminant and its significance; complex numbers (real quadratic having complex conjugate roots); relation of sum and product of roots to coefficients; first and second order differences; the factor and remainder theorem (for quadratics).

6. Graphing of quadratic functions; comparing the graphs of the functions $f(x)$, $f(x-c)$, $f(ax)$, $f(x)+c$; similarity of all graphs of quadratic functions (role of completion of square)

This is the entire prescription for a full-year course. In some classes, it may be necessary for the teacher to cover only this material and nothing else, spending the time and introducing whatever additional materials are necessary to ensure that students become fluent in the essential components. Normally, one would hope that the teacher would extend the material in some way, either through the introduction of applications, extended investigations and additional topics. It may be that the more able students in the class are given modules to work on independently possibly with the support of additional pamphlets or computer software. I do not see much point in introducing algebra tiles to the class at large - they amount to an additional code interpolated between the student and the standard code - but they may be useful for individual students who have trouble getting an initial grasp of algebra.

Other topics that might be introduced are: motion of projectiles, history of solving equations, linear and quadratic diophantine equations, Pell's equation, quadratic residues, first and second order recursions (characteristic equation), analysis of the dynamical system $x \to \lambda x(1-x)$, polynomials of degree exceeding 2; complex numbers (conjugates, modulus, geometric interpretation of sum, product and inverse, roots of unity up to the fourth); calculus of finite differences applied to polynomials interpolation and extrapolation; linear inequalities.

Course 2: Geometry of triangles and circles.

1. Triangles: congruence theorems; ambiguous case; pythagorean theorem; similarity.

2. Trigonometry: six standard ratios and basic identities ($\cos^2 + \sin^2 = 1$; $\sec^2 = 1 + \tan^2$); sine, cosine and tangents of angle sums and differences; double angle formulae; conversion formulae between sums and products; law of sines; law of cosines

3. Circles: subtended angles; cyclic quadrilaterals; tangent theorems

4. Coordinate geometry: circles; area of triangles; family of lines passing through pair of intersecting lines; circles passing through intersection of a pair of circles; radical axis; simple loci problems

Again, the teacher would have the discretion of reinforcing these core topics for students encountering difficulty, amplifying the material through applications and investigations, or moving to additional topics. These could include the following: complex numbers (use in deriving geometric and trigonometric results); vector geometry; statics; loci (conjectures, verification and proof); solid geometry; advanced Euclidean geometry; transformations and their uses (isometries and similarities; composition of isometries; isometry determined by three points; isometries generated by reflections)

The modern school, even at the secondary level, has to serve students all across the spectrum of intelligence, ability, motivation and interest, often in the same class. The only way that the system can cope with this situation is that students are trained early to become autonomous is choosing their goals and more self-propelled in accessing the resources needed to learn what they need to know and in seeking validation for their knowledge. Any system of education predicated on the

teacher being the sole source of knowledge and evaluation for the student is bound to fail; the more able and motivated will fall far short of their potential and others will not be able to really engage the material. Students must first reflect within themselves what they value and how far they are willing and able to go in achieving their goals. A successful school regime depends on certain beliefs and characteristics of students as well as the knowledge and experience of teachers; unless we recognize the need to start with this, then our principles and standards will become an exercise of merely trying to stave off the most trenchant critics from all sides and leave us seeing "men as trees walking".

Reference

1. *Principles and Standards for School Mathematics: Discussion Draft* (October, 1998) National Council of Teachers of Mathematics

RESEARCH NOTES

Noriko Yui and James Lewis

Royal Society of Canada New Fellows

Four mathematicians have been elected to the Academy of Science of the Royal Society of Canada.

Michel Fortin - Département de mathématiques et de statistique, Université Laval

Michel Fortin jouit d'une réputation internationale qui le donne pour l'un des plus éminents spécialistes de l'analyse numérique de sa génération et l'un des plus grands mathématicians appliqués que le Québec ait produits. Il est chef de file d'une vast communauté québécoise de l'analyse numérique. Ses travaux se démarquent par cette faculté qu'il possède de jeter des ponts entre la théorie et le pratique ainsi qu'entre scientifiques de disciplines différents. Fortin a apporté une contribution prégnante à la théorie des éléments finis mixtes et hybrides ainsi qu'au développment de méthodes lagrangiennes augmentées. Ce travail est résumé dans deux textes influents dont il fut le cosignitaire, *Mixed and Hybrid Finite Element Methods* et *Augmented Lagrangian Methods*.

Michael C. Mackey - Centre for Nonlinear Dynamics in Physiology and Medicine, McGill University

Michael C. Mackey is a distinguished applied mathematician who has made significant contributions to differential-delay equations and to a spectrum of mathematical topics in physiology and physics. He has made seminal contributions to biomathematics and biophysics, especially in the areas of membrane ion transport, dynamical diseases, cell replication and the dynamics of neural systems. Mackey proposed the "Mackey-Glass" delay differential equation for deterministic chaos and introduced the concept of "dynamical diseases". His widely cited book (with L. Glass), *From Clocks to Chaos: the Rhythms of Life*, showed the biological community how nonlinear dynamics and chaos theory can be used to help understand physiological systems.

Ian Fraser Putnam - Department of Mathematics and Statistics, University of Victoria

Ian Fraser Putnam has made outstanding contributions to the theory of dynamical systems. He has shown that the orbits of such systems can be completely determined by algebraic methods - methods of which he was instrumental in the development. Putnam's analysis of the structure of the C*-algebra associated with a minimal homeomorphism of the Cantor set led to an overarching scheme for the classification of all amenable C*-algebras - the so-called Elliott program. Putnam's application of the C*-algebra classification to determine the orbit structure of the Cantor set dynamical system, in terms of the quite simple C*-algebra invariant, was a striking innovation. It has changed the face of dynamical systems theory.

Maciej Zworski - Department of Mathematics, University of Toronto

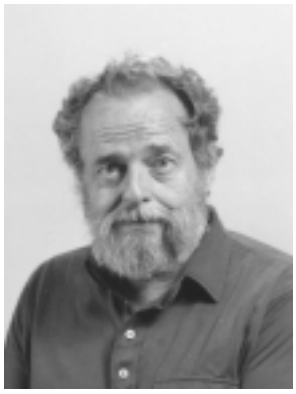
Maciej Zworski is the world's leading mathematician under the age of forty in the difficult and fundamental area of mathematics connecting partial differential equations, mathematical physics and applied mathematics. His research provides works of reference and starting points for other mathematicians. The amazing progress in the understanding of resonances in the last ten years is due largely to Zworsky. He settled a famous problem formulated by the physicist Regge thirty years ago. Zworski also found the precise location of the shadow boundary in the diffraction of linear oscillatory waves by a convex boundary, thus proving a long standing conjecture of Keller and Rubinow. This refines work dating back to the last century and was not known even on the level of formal expansions.

1999 JEFFERY-WILLIAMS LECTURE

Prime Value of Polynomials

John B. Friedlander, University of Toronto

This is a transcription of the author's Jeffery-Williams Lecture given at the CMS Summer Meeting in St. John's, Newfoundland in June of this year.



John Friedlander

ABSTRACT: Consider an irreducible polynomial with integer coefficients. It is an old and interesting problem to try to prove whether or not the polynomial is a prime number for infinitely many integer values of the variable(s). One expects that, although there are counter-examples, this will normally be the case. Nevertheless, despite the long history of the question, relatively few cases have been settled in the affirmative. In this talk we survey some of that history and then go on to describe a number of the ideas behind recent joint work with Henryk Iwaniec leading to further progress.

This lecture is concerned with two of the oldest objects of study in number theory, polynomials and prime numbers. Let $f \in \mathbb{Z}[X_1, X_2, \dots, X_r]$ be a polynomial in r variables and having integer coefficients. We shall consider the basic question

Problem 1 Does there exist an infinity of r–tuples $\mathbf{n} = (n_1, \dots, n_r) \in \mathbb{N}^r$ of positive integers such that $f(\mathbf{n})$ is a prime number?

In the few cases where we are able to show that there are we shall consider also the more refined question

Problem 2 Can we find an appropriate asymptotic formula for the counting function

$$\sum_{0<f(\mathbf{n})\le x, f(\mathbf{n})\ prime} 1 \quad ?$$

Polynomials in One Variable

We begin with what should be the most basic and interesting case, polynomials in a single variable. To start at the very beginning we take the polynomial $f(n) = n$; in other words we try to count the set of all primes. Here the first problem is answered already in Euclid: There exist infinitely many prime numbers.

The proof is so short that we give it here. Suppose to the contrary there are only finitely many, say $p_1, \dots, p_N$ and consider the integer $p_1 \dots p_N + 1$ formed by taking their product and then adding one. This integer is not divisible by any of the p_j since that division leaves a remainder of one. On the other hand, by the fundamental theorem of arithmetic, every integer exceeding one is a non-empty product of primes. This contradicts the assumption that $p_1, \dots, p_N$ exhaust the list of primes and the proof is complete.

Having answered the first problem in this case we now turn to the second problem. It took about two millennia to make this leap. In the late eighteenth century it was conjectured by Legendre that

$$\pi(x) \sim \frac{x}{\log x} ,$$

a statement that is today known as the prime number theorem. Here $\pi(x)$ denotes the number of primes up to x,

$$\pi(x) \doteq \sum_{p\le x} 1 ,$$

$\log$ is the natural logarithm, and the asymptotic symbol $f(x) \sim g(x)$ means $\lim_{x\to\infty} \frac{f(x)}{g(x)} = 1$.

Independently but perhaps a little later Gauss also conjectured the prime number theorem, this time in the form $\pi(x) \sim \operatorname{li} x$ where $\operatorname{li} x$ is the 'logarithmic integral' which we write as

$$\operatorname{li} x \doteq \int_2^x \frac{dt}{\log t} .$$

It is easy to see from repeated integration by parts that $\operatorname{li} x \sim \frac{x}{\log x}$ so that the two forms of the prime number theorem are equivalent. However it turns out that the logarithmic integral is a much closer approximation to $\pi(x)$.

It took about another century for the proof of the prime number theorem to materialize. The first important steps in this direction were taken by Chebyshev who introduced some beautiful elementary ideas and proved amongst other things

that $\pi(x)$ had the expected order of magnitude, in other words for certain positive constants c_1, c_2 and all $x \geq 2$ we have

$$c_1 \frac{x}{\log x} < \pi(x) < c_2 \frac{x}{\log x} .$$

We write this as $\frac{x}{\log x} \ll \pi(x) \ll \frac{x}{\log x}$.

The next step was taken by Riemann in an important paper of 1860. Euler had already recognized the relevance for prime number theory of what is today called the Riemann zeta function and had deduced some of its basic properties but it was Riemann who took the step of considering it as a function of a complex variable (which is truly crucial) and who mapped out a strategy whereby the properties of this function in the complex plane would lead to the proof of the prime number theorem (PNT). This programme was not so easy to complete however and it was only in 1896 and by adding ingenious ideas of their own that Hadamand and de la Vallée-Poussin succeeded in independently providing complete proofs of the PNT.

Before leaving the prime number theorem we state, partly because we shall need the relevant definitions in any case, two other equivalent forms of PNT. We mention in passing that when an analytic number theorist says that two such results are 'equivalent' it simply means that it is much easier to prove that they imply each other than it is to prove either one of them. The definition of 'much' is left to the reader. In this vague sense the PNT is equivalent to the statement that

$$\sum_{n \leq x} \mu(n) = o(x)$$

where μ is the Möbius function which is supported on the 'squarefree' positive integers (those without repeated prime factors) and for these, it satisfies $\mu(n) = (-1)^{\nu(n)}$, $\nu(n)$ being the number of distinct prime factors of n. The statement that $f(x) = o(g(x))$ means that $\lim_{x \to \infty} f(x)/g(x) = 0$.

The other equivalent form of PNT we wish to mention deals with the von Mangoldt function $\Lambda(n)$ defined to be $\log p$ for any prime power $n = p^j$, $j \geq 1$ and zero elsewhere. Then

$$\psi(x) \doteq \sum_{n \leq x} \Lambda(n) \sim x .$$

It is this form of PNT which occurs most naturally in the context of zeta-function theory.

Linear Polynomials

After the polynomial $f(n) = n$ the next natural target is the general linear polynomial $f(n) = an + b$ where of course we take $a > 0$. These are just the arithmetic progressions. In case the greatest common divisor (a, b) of a and b exceeds one then there can be only one prime in the progression since if (a, b) is divisible by some prime then so are all integers $an + b$ and no other prime value can occur. If on the other hand $(a, b) = 1$ so that the integers are 'relatively prime' then there is no obvious reason why there might not be infinitely many primes. And in fact there are. In 1837 in work that has a strong claim to being the birthplace of analytic number theory (perhaps also of representation theory) Dirichlet proved that provided $(a, b) = 1$ there are infinitely many primes $an+b$. In any case the result qualifies as this author's favourite theorem in mathematics.

Problem 1 having been solved for linear polynomials for already sixty years, it took Vallée-Poussin not very long to combine his ideas for PNT with those of Dirichlet to settle problem 2 in the general case of arithmetic progressions. Specifically he showed for $(a, b) = 1$,

$$\sum_{n, an+b \leq x} \Lambda(an + b) \sim \frac{1}{\varphi(a)} \frac{x}{a}.$$

Here $\varphi(a)$ denotes Euler's function, the number of reduced residue classes modulo a, i.e. the number of b, $1 \leq b \leq a$ with $(a, b) = 1$. Thus each of the eligible arithmetic progressions of modulus a receives asymptotically the same number of primes.

Although problems 1 and 2 have thus been settled the question of the size of the error term in the asymptotic formula is still rather poorly understood. This remains a central problem in the subject and includes within it one of the most famous conjectures in mathematics, the (generalized) Riemann Hypothesis.

Higher Degree

We turn next to single variable polynomials of higher degree. Here it is easy to see that in order to take an infinitely many prime values such a polynomial must be irreducible (over the rationals) and primitive (i.e. not having all coefficients divisible by the same prime). One might think that, as in the linear case, these conditions are also sufficient and that any irreducible polynomial with relatively prime coefficients should represent infinitely many primes. That the situation is not quite so simple is exemplified by the polynomial $f(n) = n^2 + n + 2$ which at first glance might appear a reasonable candidate but when re-written as

$$f(n) = n(n + 1) + 2$$

is visibly always an even integer. Nevertheless we expect this to be exceptional and that the result holds for most irreducible polynomials. However it is not known to hold for any single polynomial (of degree > 1). It is not even known that there exists such a polynomial.

An impressive example is given by the 'Euler-Rabinowitz' polynomial $n^2 + n + 41$ which is prime for each of the values $n = 0, 1, 2, \ldots, 39$. Despite getting off to such a good start in life it is not known to be prime infinitely often. There are interesting connections between the prime values of $n^2 + n + a$ and the arithmetic of the quadratic number field $Q(\sqrt{1 - 4a})$ but that is another story.

The simplest looking example n^2+1 constitutes one of four famous problems mentioned in a lecture by Landau as problems for the twentieth century. The others were the Goldbach conjecture (that every even integer ≥ 4 is the sum of two primes), the twin prime problem (that there are infinitely many pairs of primes differing by two), and finally the problem of showing that between every pair of consecutive squares there is a prime. Despite Landau in posing four such problems having been apparently less demanding than had Hilbert in his famous lecture about the same time, this has turned out after all not to be the case. One hundred years later none of Landau's four problems have been solved.

Conjectures however have been easier to come by, in the case of problem 2 as well as problem 1. Thus, for the polynomial n^2+1 Hardy and Littlewood conjectured that

$$\sum_{n,n^2+1\leq x} \Lambda(n^2+1) \sim x^{\frac{1}{2}} \prod_{p>2} \left(1-\frac{\chi(p)}{p-1}\right)$$

where $\chi = \chi_4$ is the Dirichlet character of modulus four which is supported on the odd positive integers, defined to be $+1$ at primes of the form $4m+1$, to be -1 at primes $4m-1$, and extended to all odd integers by multiplicativity.

This conjecture is just a special case of more general conjectures due to Hardy-Littlewood to Schinzel, and to Bateman-Horn which deal with more general polynomials and also to simultaneous primality of more than one polynomial. The twin prime problem which deals with the simultaneous primality of n and $n+2$ is an example of the latter.

Restricting ourselves to the case of a single polynomial we have the following. Let $f \in \mathbb{Z}[X]$ be irreducible with positive leading coefficient. Define the 'volume'

$$V(x) = V_f(x) = \sum_{n,f(n)\leq x} 1 \, .$$

Then

Conjecture:

$$\sum_{n,f(n)\leq x} \Lambda(f(n)) = c_f V(x) + o(V(x))$$

where

$$c_f = \prod_p \left(1-\frac{\nu(p)}{p}\right)\left(1-\frac{1}{p}\right)^{-1}$$

with $\nu(p)$ the number of roots of $f(n) \equiv 0 \ (modulo\ p)$. It is not even so obvious that the above infinite product $\prod_p$ is convergent but in fact it turns out that it does.. This follows from the 'prime ideal theorem' which is the generalization of the prime number theorem to algebraic number fields. Nevertheless, it is possible for the constant c_f to vanish in case $\nu(p) = p$ for some prime p. Thus recall our earlier example $f(n) = n^2+n+2 = n(n+1)+2$ which is always even so that $\nu(2) = 2$.

More than One Variable

Having seen limited success dealing with polynomials in one variable it might seem foolhardy to further complicate matters by adding more variables. Surprisingly the problem gets easier. Eventually, it is no longer a problem about primes. Thus for example consider the polynomial

$$m^2+n^2+r^2+s^2 \, .$$

By a famous theorem of Lagrange we obtain every positive integer, and so of course every prime.

More generally we have, as first conjectured by Waring, a similar result for higher powers, specifically

Theorem (Hilbert). For each $k \in \mathbb{N}$, there exists $g(k) \in \mathbb{N}$ such that every positive integer is the sum of $g(k)$ k–th powers.

In fact with enough variables we can even construct ...

Theorem (Matijasevic, 1977). There is a function $f \in \mathbb{Z}[X_1, X_2, \ldots, X_{10}]$ whose positive range is just precisely the set of primes.

Actually this is a refinement of his breakthrough result a few years earlier. The following example of such a polynomial which I learned about from Ribenboim's book of prime number records is due to Jones, Sato, Wada and Wiens in 1976. It is a convenient example for English speaking people, containing 26 variables $a, \ldots, z$.

(k+2) $\Big\{ 1-[wz+h+j-q]^2 - [(gk+2g+k+1)(h+j)+h-z]^2$
$-[2n+p+q+z-e]^2 - [16(k+1)^3(k+2)(n+1)^2+1-f^2]^2$
$-[e^3(e+2)(a+1)^2+1-o^2]^2 - [(a^2-1)y^2+1-x^2]^2$
$-[16r^2y^4(a^2-1)+1-u^2]^2 - [((a+u^2(u^2-a))^2-1)(n+4dy)^2$
$+1-(x+cu)^2]^2 - [n+l+v-y]^2$
$-[(a^2-1)l^2+1-m^2]^2 - [ai+k+1-l-i]^2$
$-[p+l(a-n-1)+b(2an+2a-n^2-2n-2)-m]^2$
$-[q+y(a-p-1)+s(2ap+2a-p^2-2p-2)-x]^2$
$-[z+pl(a-p)+t(2ap-p^2-1)-pm]^2 \Big\}$.

In general so far we can deal with a number of cases for all of which we have

$$V_f(x) \geq \frac{x}{(\log x)^B}$$

for some B and all large x. For the simplest looking polynomials this usually means we require the number of variables to be at least as large as the degree. (This is not quite always the case since for example if the polynomial is linear in one of the variables we get a positive proportion of integers simply by fixing appropriately each of the other variables.)

Two Variables

If we accept the premise that more variables makes things easier, that the fewer the variables the more basic and interesting the problem, but that one variable seems too difficult, it

becomes natural to try next to consider two variables. By the remarks in the previous paragraph we might expect to be able to deal with linear and quadratic polynomials but not beyond this.

The case of linear polynomials might well be an exercise in books in elementary number theory. The general polynomial of this type looks like $\alpha r+\beta s+\gamma$ where α, β, γ are fixed integers. One of the first basic results of elementary number theory is the theorem that as r, s run through $\mathbb{Z}$, $\alpha r + \beta s$ runs through all multiples of the greatest common divisors (α, β). Hence $\alpha r + \beta s + \gamma$ runs through all integers in the arithmetic progression γ modulo (α, β) and by Dirichlet's theorem we merely need to know whether γ has a non-trivial factor in common with (α, β), equivalently whether α, β, γ are all divisible by the same prime.

The case of quadratic polynomials in two variables is a rich subject with a distinguished history. Fermat considered the basic case of $r^2 + s^2$. It is easy to see that no prime $\equiv 3 \pmod 4$ is the sum of two squares since in fact even no integer $\equiv 3 \pmod 4$ can be. Fermat proved the considerably deeper fact that every prime $\equiv 1 \pmod 4$ is the sum of two squares. Following important subsequent work by Euler, Lagrange and Gauss, the issue was settled for all primitive, irreducible binary quadratic 'forms' (i.e. homogeneous polynomials)

$$\alpha r^2 + \beta rs + \gamma s^2 \ ,$$

by Dirichlet. For the more general non-homogeneous quadratic polynomials f the result waited much longer and is due to Iwaniec (in his undergraduate days).

It is easy to see that for these we need that f represent arbitrarily large odd integers and that we require $\frac{\partial f}{\partial r}$, $\frac{\partial f}{\partial s}$ to be linearly independent. These two conditions turn out to be sufficient. The density of primes represented turns out to depend on a rather technical condition which we do not state. For one class of polynomials, which includes the forms, the number of primes $\leq x$ has order of magnitude $x/\log x$ while for the remaining polynomials there are somewhat fewer, namely order $x/(\log x)^{3/2}$. A typical example from this class is the polynomial $r^2 + s^2 + 1$.

Higher Degree

We now describe some more recent work, joint with H. Iwaniec, in which we solve problems 1 and 2 for the polynomial $x^2 + y^4$. For this polynomial one has $V_f \sim cx^{\frac{3}{4}}$ so this is a much thinner set than those that had been treated earlier. The work appeared a few months ago in late 1998 in Annals of Mathematics.

Theorem (F-I): There are infinitely many primes of the form $r^2 + s^4$. Moreover

$$\sum\sum_{r>0 \ s>0, r^2+s^4\leq x} \Lambda(r^2 + s^4) \sim \frac{4}{\pi}\kappa x^{\frac{3}{4}}$$

where $\kappa = \int_0^1 (1 - t^4)^{\frac{1}{2}} dt$.

Corollary: $\sum\sum_{r>0 \ s>0, r^2+s^4=p<x} 1 \sim \frac{4}{\pi}\kappa \frac{x^{\frac{3}{4}}}{\log x}$.

It is interesting to compare this asymptotic formula with the well-known corresponding one for $r^2 + s^2$. To obtain the latter one merely replaces $x^{\frac{3}{4}}$ by x and t^4 by t^2. The elliptic integral κ now becomes the area of $\frac{1}{4}$ of the unit disc namely $\frac{\pi}{4}$ which cancels with the other factor $\frac{4}{\pi}$. The two formulas tell us that the 'probability' of a given integer $r^2 + s^2$ being prime is the same when we are told that s is a square as it is when we are told that s is not a square.

Although our work was restricted to the single polynomial $r^2 + s^4$ there are a number of possible extensions, with varying chances for success.

(A) The values of the polynomial $r^2 + s^4$ are treated in our work as the special values $\varphi(r, s^2)$ of the binary quadratic form $X^2 + Y^2$. One can attempt to similarly treat the prime values of $\varphi(r, s^2)$ for φ a general binary quadratic form. It seems highly likely that this will succeed but there are lengthy details to be checked.

(B) More problematic is the possible extension to prime values of $\varphi(r, s^3)$ or even $\varphi(r, s^4)$. In this case there is some hope but some of the remaining obstacles seem extremely serious. The case of $ar^2 + bs^6$ would be of particular interest in connection with discriminants of elliptic curves.

(C) By contrast prime values of $r^4 + s^4$ seem hopelessly out of reach at this time.

Sieve Methods

We sketch a little bit about the ideas behind the proof, which is based on a sieve method.

Let $\mathcal{A} = (a_n)$ be a sequence of non-negative real numbers. Often in practice this is just the characteristic function of an interesting set of positive integers (and occasionally one ignores the distinction between the set and its characteristic function). In our example a_n will be the number of representations of n in the form $n = r^2 + s^4$. Our goal is to study the sum

$$S = \sum_{n\leq x} a_n \Lambda(n) \ .$$

We write $\Lambda(n) = \sum_{d|n} \lambda_d$ where this means the sum is over the positive integers which divide n. Any function on the positive integers (i.e. arithmetic function) can be so written. This follows from the 'Möbius inversion formula'. In our case it turns out that $\lambda_d = -\mu(d) \log d$ where μ is Möbius function defined early in the lecture. If we inject this formula for Λ into that for S we obtain a double sum. It is a well-known

mathematical axiom that all double sums are given to you in the wrong order so we interchange this obtaining

$$S(x) = \sum_{x \le x} \lambda_d A_d(x)$$

where

$$A_d(x) = \sum_{n \le x, n \equiv 0 (\mathrm{mod}\, d)} a_n$$

and in particular $A(x) = A_1(x)$ is the total mass of the sequence up to x.

To see what is involved here it is useful to recall the sieve of Eratosthenes wherein one wants to count the primes up to x. One begins with the set of positive integers up to x and casts out all multiples of two, of three, and so on. If one wants to count the number of remaining integers one needs first to count the number deleted at each step, the number divisible by two, by three, by a general integer d.

In general we assume that we can write

$$A_d(x) = g(d)A(x) + r_d(x)$$

where g is a 'nice' function and r (= remainder) is small at least on average over d. We shall need a number of assumptions about the function g but these are not the central issue. Think of $g(d) = \frac{1}{d}$ as the prototype of such functions. It is the one that occurs in the last example mentioned. Half of the integers up to x are even, about $\frac{1}{d}$ of them are divisible by d. In general g behaves like a probability. Indeed we assume $0 \le g(p) < 1$ for every prime p and that g is 'multiplicative' in the sense that $(m, n) = 1 \Rightarrow g(mn) = g(m)g(n)$. There are other more technical assumptions, for example

$$\sum_{p \le x} g(p) \log p \sim \log x \, .$$

In the case of the prototype $g(d) = \frac{1}{d}$ this assumption is a theorem, proved by Chebyshev. There are a few other similar assumptions we do not mention. More important is the axiom about r: We assume

$$\sum_{d<D} |r_d(x)| \le A(x)(\log x)^{-1998} \qquad (R)$$

for some D with $x^{\frac{2}{3}+\varepsilon} < D < x$.

Here of course 1998 is chosen for historical purposes, the main point being that $A(x)$ represents essentially the trivial bound and we need to save from this only some number of logarithms. What is more important is that we need D to be as large as possible.

We remark that in practice it is impossible to obtain $D > x$ or even $D > A(x)$ the mass of the sequence. In the case of our problem we were inspired by the following result.

Theorem (Fouvry-Iwaniec): Let $\varepsilon > 0$. Then for the sequence a_n = number of representations of $n = r^2 + s^4$, assumption (R) holds with $D = x^{\frac{3}{4}+\varepsilon}$.
In view of our previous remark this theorem is, apart from the ε, best possible.

The above assumptions lead to what might be called the 'classical' sieve. Over the years we have learned that it is not possible to produce primes from the classical sieve due to a phenomenon known as the 'parity problem' first pointed out by Selberg and described very precisely by Bombieri in his work on the 'asymptotic sieve'.

To illustrate this problem we consider the simplest case of what are known as the Selberg counter-examples. We take

$$\mathcal{A} = \{n \le x, \Omega(n) \text{ even}\}$$

when $\Omega(n)$ counts the number of prime factors of n, multiplicity included. Thus $\mathcal{A}$ obviously contains no prime numbers at all. But it can be shown that this sequence satisfies all of the classical sieve axioms and with D in (R) essentially as large as possible.

To get around this problem we add on a new sieve axiom:

$$\sum_m \Big| \sum_{N<n\le 2N, mn \le x} \mu(mn) a_{mn} \Big| \le A(x)(\log x)^{-1998} \quad (B)$$

for all N satisfying $x^{-\delta}\sqrt{D} < N < x^{\frac{1}{2}}(\log x)^{-\beta}$ for some $\beta > 0$, $\delta > 0$.

A good sign is provided by the fact that the new axiom (B) is not satisfied by the sequence in the Selberg example, since the Möbius function μ does not change sign on $\mathcal{A}$ but is equal to one for all squarefree mn. Hence we have at least a chance to get primes.

And in fact we do.

Theorem (F-I): Under the 'above' assumptions

$$\sum_{n \le x} a_n \Lambda(n) \sim HA(x)$$

where

$$H = \prod_p (1 - g(p)) \Big(1 - \frac{1}{p}\Big)^{-1} \, .$$

Of course our assumptions have not been quite precisely stated here and any reference should be to the formal statements in the paper.

The potential of this sieve method is very good indeed. It has the capability to settle such important questions as the Goldbach conjecture, the twin prime conjecture, etc.! There is however a problem, and quite a huge one at that.

How do we prove that the assumption (B) holds for the relevant sequence? Even a proof of (R) with such a high level D is quite a serious issue. Thus for example for the twin prime or Goldbach problems the fact that (R) holds with $D = x^{\frac{1}{2}-\varepsilon}$ follows from the famous Bombieri-Vinogradov

theorem while it would also follow even with $D = x^{1-\varepsilon}$ from a well-known conjecture of Elliott and Halberstam.

In the case of our example (R) holds with $D = x^{\frac{3}{4}-\varepsilon}$ by the above mentioned theorem of Fouvry and Iwaniec and hence we need to obtain (B) for all $N > x^{\frac{3}{8}-\delta}$ for some δ. We are actually able to obtain it for all $N > x^{\frac{1}{4}+\varepsilon}$ for every fixed $\varepsilon > 0$ (and of course N bounded above as in the statement of (B)). The proof of this is long and technical (over 80 pages) and we cannot hope to discuss it here. We do mention one out of a number of aspects which seem of independent interest and that come up along the way.

Byproduct on Jacobi Symbols

Let us recall the Legendre symbol, defined for p an odd prime and a an integer not divisible by p as

$$\left(\frac{a}{p}\right) = \begin{cases} 1 & \text{if } a \equiv \ square (\mathrm{mod}\, p) \\ -1 & \text{else} \end{cases}$$

so that in the canonical projection of $\mathbb{Z}$ onto the field of p elements those integers a with $\left(\frac{a}{p}\right) = 1$ are just those which project onto non-zero squares.

The Jacobi symbol is a natural linear extension of the Legendre symbol defined for $b = \prod_p p_j^{\alpha_j}$ odd and $(a, b) = 1$ by $\left(\frac{a}{b}\right) = \prod_j \left(\frac{a}{p_j}\right)^{\alpha_j}$.

These symbols are examples of Dirichlet characters and it is an important oft-studied problem to show that sums $\sum \left(\frac{a}{b}\right)$ as a (or b, or both) run through a given set (often an interval) are small, i.e. asymptotically half of them give $+1$, and half -1.

We have

Theorem (Fermat): If $p \equiv 1 (\mathrm{mod}\, 4)$ is prime then $p = a^2 + b^2$ where $a > 0$, $b > 0$, a even, b odd in a unique fashion.

Thus to each such prime we can associate in a natural fashion a Jacobi symbol $\left(\frac{a}{b}\right)$. Sums over these are much more complicated than sums over intervals. We were able to show

Theorem (F-I):

$$\sum_{p \le x, p = a^2 + b^2} \left(\frac{a}{b}\right) \ll x^{\frac{76}{77}} .$$

Since the trivial bound is of order $\frac{x}{\log x}$ it follows that asymptotically half of the time the symbol is 1 and half -1.

Conclusion

We have earlier been lamenting how little is known about the most basic problems concerning prime values of polynomials. On the other hand, just one hundred years ago (well, make that one hundred and ten) we did not know how to prove the prime number theorem. The sieve had hardly advanced at all beyond its ancient Eratosthenian beginnings. So maybe we should not be so pessimistic. It would be nice to know what the next one hundred and ten years will bring.

(MATH–continued from page 1)

years remaining in high school and with the potential to compete at the mathematical olympiad level.

The Imperial Oil Charitable Foundation has agreed to be the title sponsor for the 1999 Regional and National Math Camps and, as they stated in a recent media release, "we're proud to support the Esso Math Camps as they provide an opportunity for Canadian students to explore the many uses of mathematics in today's society and, in addition, these camps help students to pursue careers in high technology, science and business".

The 1999 Esso National Math Camp took place at the University of Waterloo from June 19 to 25. The University of Calgary hosted an Esso regional camp from July 17 to 23 and the University of Western Ontario hosted one from August 10 to 12. Dalhousie University will be hosting a regional math camp this fall. The national camp in Waterloo and the regional camp in Calgary were both residence camps lasting about a week while the camp at the University of Western Ontario was a day camp and the regional camp at Dalhousie University will be a series of weekend camps. Naturally, the costs associated with the camp depends upon the format followed.

These camps provide an excellent opportunity for students to spend time at the host university, have fun doing mathematics, establish some very useful contacts with fellow students as well as get to know some other mathematics teachers. The camps that have taken place have been very successful and the CMS is delighted that so many students have written expressing their appreciation and commenting on how much they enjoyed them. I would like to thank all of those who have helped make the 1999 Esso Math Camps a reality and for all their efforts to provide the participants with a rewarding experience and an excellent learning environment.

As part of World Math Year 2000, and with further support from the private sector and host universities, the CMS wishes to expand the programme so that math camps can take place in more provinces and cities. Information on those camps that have taken place and *a model for a regional math camp* can be found at the CMS web site (http://www.cms.math.ca/MathCamps/). This programme has many benefits for all of those involved and I invite colleagues to contact me if they are interested in participating.

DU BUREAU DU DIRECTEUR ADMINISTRATIF

Pour que les mathématiques, ça compte

(see page 1 for the English version)

Au moment de la mise en oeuvre de la campagne de souscription “Les mathématiques, ça compte!”, nous avions bon espoir d’atteindre un niveau élevé de soutien et de reconnaissance des activités dans les domaines de la recherche et de l’éducation de notre Société. Notre déception sur certains plans ne doit pas nous empêcher de nous réjouir de nos succès.

Le soutien que nous ont accordé les universités hôtes et les trois instituts de recherche nous a permis d’augmenter les programmes de nos réunions semestrielles et, ainsi, accroître le nombre de participants de façon importante. Nous souhaitons que cette situation, très positive, se poursuive au moment de nos prochaines réunions.

La réunion d’hiver 1999 à Montréal offre non seulement un excellent programme scientifique, mais également, et pour la première fois, un Carrefour emploi. Ce numéro des NOTES présente des informations à ce propos. Nous espérons que se poursuive cette importante collaboration entre l’université hôte, les instituts de recherche, le secteur privé et la Société et qu’il y ait dorénavant un Carrefour emploi à chaque réunion semestrielle de la SMC. Je suis heureux d’annoncer que tous les endroits des prochaines réunions jusqu’en l’an 2004 sont maintenant déterminés et je suis persuadé que chacun des présidents et organisateurs va tout mettre en oeuvre pour offrir un excellent programme scientifique.

Dans le numéro de septembre des NOTES, Daryl Tingley nous a entretenus du banquet des lauréats de la SMC de juin dernier ainsi que de tout le soutien reçu de la part des entreprises, des gouvernements ainsi que des membres de la SMC dans le cadre de nos divers concours. Cela faisait plaisir de voir les médias accorder tant d’intérêt au talent mathématique. C’est très encourageant de constater que nos activités éducatives soulèvent de plus en plus d’intérêt et font l’objet de plus en plus de reportages.

Je suis tout particulièrement enthousiasmé de l’intérêt et du soutien qu’a reçu le programme de la SMC des camps mathématiques. Bien que les camps d’entraînement d’été et d’hiver de l’OIM existent depuis plusieurs années, la SMC voulait élaborer un programme de camps régionaux et national à la portée et à l’attrait encore plus vastes. Les camps régionaux sont des camps d’enrichissement destinés principalement aux étudiants canadiens de la 8e à la 10e année (de la deuxième année à la quatrième année du secondaire), tandis que le camp national s’adresse d’abord aux jeunes étudiants canadiens à qui il reste encore au moins deux ans de secondaire et qui ont le potentiel nécessaire pour participer aux olympiades mathématiques.

La Fondation philanthropique Pétrolière Impériale a accepté d’être le commanditaire en titre des camps national et régionaux de 1999. “Nous sommes fiers d’offrir ce soutien aux camps mathématiques Esso, car ces derniers permettent aux jeunes Canadiens d’explorer les multiples usages des mathématiques dans la société actuelle”, affirmait-elle récemment dans un communiqué de presse. “De plus, ces camps aident les étudiants à poursuivre des carrières dans les domaines de la haute technologie, des sciences et de l’administration.”

Le Camp national de mathématiques Esso a eu lieu à l’Université de Waterloo, du 19 au 25 juin. Les Universités de Calgary et de Western Ontario ont respectivement tenu un camp régional Esso du 17 au 23 juillet et du 10 au 12 août. L’Université Dalhousie aura son tour cet automne. Le camp national et le camp régional de Calgary duraient environ une semaine et adoptaient tous deux la forme de camp-séjour; celui de Western Ontario, quant à lui, était un camp de jour et, enfin, celui de Dalhousie sera offert en une série de camp de fin de semaine. Bien sûr, les coûts varient en fonction de la formule adoptée.

Ces camps représentent une excellente occasion pour les étudiants de visiter l’université hôte, de s’amuser en faisant des mathématiques, de créer de précieux contacts avec des compagnons ou compagnes d’études ainsi que faire la connaissance de nouveaux professeurs de mathématiques. Les camps qui ont déjà eu lieu ont remporté un vif succès! La SMC se réjouit de constater le nombre élevé d’étudiants qui ont lui écrit pour exprimer leur appréciation et leur bonheur. J’adresse mes remerciements chaleureux à tous ceux qui ont contribué à faire des camps mathématiques Esso 1999 une heureuse réalité; grâce à leur efforts dévoués, les participants ont vécu une expérience enrichissante dans un excellent contexte d’apprentissage.

Dans le contexte de l’an 2000, année internationale des mathématiques, et grâce au soutien continu du secteur privé et des universités hôtes, la SMC souhaite étendre encore davantage le programme pour qu’un plus grand nombre de provinces et de villes puissent offrir des camps mathématiques. On peut trouver les informations sur les camps de cette année ainsi qu’un modèle de camp régional au site Web de la SMC (http://www.cms.math.ca/MathCamps/). Tous ceux qui oeuvrent à ce programme y trouvent grand profit et j’invite tous mes collègues à me faire part de leur intérêt à y participer.

AWARDS / PRIX

1999 Canada Wide Science Fair - CMS Awards

The CMS sponsored a set of three Special Awards at the 1999 Canada Wide Science Fair in Edmonton. There were some wonderful projects at the fair, and we would have loved to be able to give out more than one prize in each category. But each category had one clear winner. All judges on the CMS team were unanimous about the winner, so that made our jobs relatively easy. Below are the project descriptions of the three prize-winning entries.

Chaos in the Arctic

Junior – Adrian Maler (Grade 8)

The objective was to discover a model that would predict population dynamics. I tried to model population growth with the logistic equation and a "coupled logistic equations" model that I developed.

Palindrome Problems

Intermediate – Katie McAllister (Grade 9)

The problem of this project is to investigate palindrome numbers and to look for relationships among palindromes in different bases.

In Search of Perfection

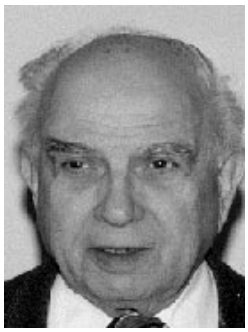
Senior – Jocelyn Land-Murphy (Grade 13)

The purpose of my study was to produce a general formula for generating the factors of perfect numbers.

*****

A few of the particicpants voluntarily expressed appreciation for having "real" mathematicians talking to them about their work. It was clear that they felt many other judges did not really appreciate and/or understand the work, and their faces lit up when they figured out we understood what they were talking about. This certainly underscored the presence of the CMS at this event!

Order of Canada



Nathan Mendelsohn

Professor Nathan Mendelsohn of the University of Manitoba has been named a Member of the Order of Canada.

Professor Mendelsohn was born in 1917 and graduated from the University of Toronto in 1942, where he obtained the Ph.D. under the supervision of G. de B. Robinson. He worked as a government research scientist during the war, moving to Manitoba in 1947. He was Head of the Department of Mathematics and Astronomy 1963-1989 and became the university's first distinguished professor in 1989. He was elected a Fellow of the Royal Society of Canada in 1956 and was awarded the Society's Henry Marshall Tory Medal in 1979. His contributions to the wider mathematical community have been manifold, including service as President of the CMS 1969-1971. In 1995 he received the CMS Award for Distinguished Service.

He has published more than a hundred research papers, mainly in the areas of geometry and combinatorics.

University of Waterloo Distinguished Teaching Award

Ron Scoins

Ron Scoins is the recipient of the Distinguished Teaching Award for 1999 at the University of Waterloo. The award is made by the University Senate on nomination by the students of the instructor, supported by the Dean and a university-wide committee of faculty and students.

Ron Scoins taught secondary school mathematics in the Waterloo region for 13 years. Having taught all levels of students in all grades and served as Department Head he brought an appreciation for students of all types and interests when he joined the Faculty of Mathematics in 1974.

Since then he has been a lecturer, Director of the Mathematics Cooperative Teaching Option, a major developer of the Canadian Mathematics Competition, and is currently Associate Dean, External Affairs, in the Faculty of Mathematics.

He is recognized for his exemplary teaching, his readiness to provide students with individual assistance at anytime, and his strong support of student issues and concerns.

The CORS Corner

Laura Logan, CORS President

As you may be aware, CORS (Canadian Operational Research Society) has started submitting regular articles to the NOTES. The first was in the previous issue and gave an overview of the Society and its activities. It was written by Dr. Rick Caron who was President of the Society until early June of this year. At our annual conference, which this year was held in Windsor, Ontario, I took over the presidency. I am honoured to be able to continue this cooperation between our societies. I would like to take this chance to describe the Society and its activities in a little more detail so that you can get to know us better.

CORS is a group of people, both practitioners and academics, who are trying to promote the awareness of Operational Research and its many applications. There are many aspects to this work and this is where I will concentrate this time:

- CORS represents Operational Researchers in policy issues involving NSERC and SSHRC. This activity is headed up by the academics within the group.
- CORS works to make students aware of Operational Research and its potential by having student sections at various universities, awarding CORS Diplomas to those students at participating universities who complete a curriculum that provides a strong foundation of OR techniques, and funding travel for student members to attend the annual conference.
- CORS annual conferences are an excellent forum for building and maintaining strong links within the Canadian OR community. There is a wide variety of high quality presentations and excellent discussions outside the sessions. The conference is also the time for CORS to present its annual awards. The conferences attract a large number of people from outside Canada and every few years are hosted jointly with INFORMS or IFORS (the American and International societies, respectively).
- CORS has sections in each of the major cities or regions of the country. The local sections host their own events throughout the year so that everyone has a chance to get to know the other people in their area.
- CORS has two regular publications. The Bulletin is our newsletter that is sent to the members 4 or 5 times a year. It keeps the members up to date with the activities of the society and the other members. INFOR is the technical journal published in conjunction with CIPS, the Canadian Information Processing Society. It is a well-regarded journal with a global subscription base.

There are lots of other projects and services, but I should leave something for another time. If you have any questions or comments, please feel free to check out our Web site at www.cors.ca or e-mail me at llogan@aircanada.ca.

CMS WINTER MEETING 1999 RÉUNION D'HIVER DE LA SMC
RENAISSANCE - HÔTEL DU PARC
3625, Avenue du Parc, Montreal (Québec) Canada

LECTURES : Conference Center — **SCHEDULE - HORAIRE** — **CONFÉRENCES : Centre de Conférence**

Time Heure	Thursday / jeudi December 9 décembre	Friday / vendredi December 10 décembre	Saturday / samedi December 11 décembre	Sunday / dimanche December 12 décembre	Monday / lundi December 13 décembre
8:00			Registration open from 8:00 a.m. to 5:00 p.m. Bureau d'inscription ouvert de 8:00 à 17:00 Coffee will be available in the Exhibit area / Le café sera servi dans l'aire d'exposition		
			12:00 - 17:00 Exhibits - Expositions	8:00 - 17:00 Exhibits / Expositions	
8:30			8:30 - 9:00 Opening Remarks Mots de bienvenue		
9:00			9:00 - 9:50 **ADRIANO GARSIA**	9:00 - 9:50 SESSIONS	9:00 - 9:50 **JIAN SHEN** CMS DOCTORAL PRIZE
10:00			10:00 - 10:30 **COFFEE BREAK / PAUSE CAFÉ**		
10:30	9:00 - 16:00 Executive Committee Meeting Réunion du Comité exécutif Salon Jeanne-Mance Conference Center		10:30 - 11:20 **PAVEL A. PEVZNER**	10:30 - 11:20 **ZHIHONG XIA**	10:30 - 11:20 **ANDREAS DRESS**
11:00		11:00 - 13:00 CMS Development Group Groupe de développement Salon Laurier Conference Center			
11:30			11:30 - 14:00 **DELEGATES' LUNCHEON** **LUNCH DES PARTICIPANTS** Renaissance-Hôtel du Parc	11:30 - 12:30 SESSIONS	11:30 - 12:30 SESSIONS
12:30				12:30 -14:00 **LUNCH / DÉJEUNER**	12:30 - 14:00 **LUNCH / DÉJEUNER**
13:00		13:30 - 18:30 Board of Directors Meeting Réunion du Conseil d'administration Salon Des Pins Renaissance-Hôtel du Parc			
14:00			14:00 - 15:00 **DAVID C. LAY** EDUCATION PLENARY	14:00 - 15:00 **MACIEJ ZWORSKI** COXETER-JAMES LECTURE	14:00 - 15:00 **ELLIOTT H. LIEB**

CMS WINTER MEETING 1999 RÉUNION D'HIVER DE LA SMC
RENAISSANCE - HÔTEL DU PARC
3625, Avenue du Parc, Montreal (Québec) Canada

LECTURES : Conference Center — **SCHEDULE - HORAIRE** — **CONFÉRENCES : Centre de Conférence**

15:00	9:00 - 16:00 Executive Committee Meeting Réunion du Comité exécutif Salon Jeanne-Mance Conference Center	13:30 - 18:30 Board of Directors Meeting Réunion du Conseil d'administration Salon Des Pins Renaissance-Hôtel du Parc	15:00 - 15:30 **COFFEE BREAK / PAUSE CAFÉ**		
15:30			15:30 - 17:30 SESSIONS	15:30 - 17:30 General Meeting Assemblée Générale 17:30 - 18:30 SESSIONS	15:30 - 18:30 SESSIONS 17:30 - 19:30 Forum on the teaching of linear algebra Forum sur l'enseignement de l'algèbre linéaire
Evening		19:00 - 21:00 Reception Cash-bar and Evening Registration Réception (bar payant) et inscription Renaissance-Hôtel du Parc	18:00 - 18:30 Reception (Cash bar) 18:30 - 19:30 **JENNIFER CHAYES** PUBLIC LECTURE	18:30 - 19:00 Reception (Cash bar) 19:00 - 22:00 Banquet Renaissance-Hôtel du Parc	

CMS Winter 1999 Meeting
Renaissance - Hôtel du Parc
Montréal, Québec
December 11 - 13, 1999

Third Announcement

Please refer to the Second Announcement in the September issue of the *CMS Notes* for more complete information on the scientific, education and social programmes. This announcement features a preliminary timetable and any changes to the programmes previously announced. The most up-to-date information concerning the programmes, including scheduling, is available at the following world wide web address:

http://www.camel.math.ca/CMS/Events/

Meeting registration forms and abstract forms for contributed papers may be found in the September issue of the *CMS Notes* and at our website.

Programme Updates

Department Chairs' Luncheon: As the CRM is organizing a meeting of Chairs from Canadian Mathematics Departments on November 20-21, 1999, the usual December luncheon of Department Chairs is not yet confirmed.

Symposium on History of Mathematics: The list of speakers for this symposium include Tom Archibald (Acadia), Edward Barbeau (Toronto), Len Berggren (Simon Fraser), Louis Charbonneau (UQAM), Chongs Suh Chun (Athabasca), Florin Diacu (Victoria), Hardy Grant (Carleton), Minoru Hasegawa (Lakehead), Jacques Lefebvre (UQAM), Gregory Moore (McMaster), Richard O'Lander (St. John's University, USA), Dana Schlomiuk (Montreal), Ronald Sklar (St. John's University, USA), Viena Stastna (Calgary), George Styan (McGill), and Peter Zvengrow (Calgary).

Acknowledgements

The support of the following organizations is gratefully acknowledged:
- Centre de recherches mathématiques
- Institut des sciences mathématiques
- Laboratoire de combinatoire et d'informatique mathématique
- Network for Computing and Mathematical Modeling
- The Fields Institute for Research in Mathematical Sciences
- The Pacific Institute for the Mathematical Sciences.

The CMS wishes to acknowledge the contribution of the members of the Meeting Committee for organizing this meeting and presenting these exciting scientific, educational, and social programs.

Meeting Committee

Meeting Director: Michel Delfour (Montréal)
Local Organizing Committee Chair: Véronique Hussin (Montréal).
François Bergeron, Nantel Bergeron, George Bluman, Monique Bouchard (CMS ex-officio), Martin Goldstein, Michel Grundland, Lucien Haddad, Pierre Hansen, Joel Hillel, Jacques Hurtubise (CMS ex-officio), Jacqueline Klasa, François Lalonde, Gilbert Laporte, Benoît Larose, Sabin Lessard, Paul Libbrecht, Wendy MacCaull, Thomas Mattman, Angelo Mingarelli, Richard O'Lander, Ivo Rosenberg, Christiane Rousseau, David Sankoff, Phil Scott, Ronald Sklar, Gordon Slade, Graham Wright (CMS ex-officio), Mike Zabrocki.

Items also published with this announcement

Timetable - block schedule

In the next issue of the *CMS Notes*

Fourth Announcement
Updated Timetable - block schedule

Réunion d'hiver de la SMC
Renaissance Hôtel du Parc
Montréal (Québec)
du 11 au 13 décembre, 1999

Troisième annonce

Veuillez consulter la deuxième annonce dans le numéro de septembre des *Notes de la SMC* pour obtenir de l'information détaillée sur les programmes scientifique et pédagogique, et les activités sociales. La présente annonce contient l'horaire et tous les changements aux programmes annoncés précédemment. Vous trouverez l'information la plus récente sur les programmes, y compris les horaires, à l'adresse Web

suivante:

http://www.camel.math.ca/CMS/Events/

Un formulaire d'inscription et un formulaire de résumé pour communications libres étaient inclus dans le numéro de septembre des *Notes de la SMC* et au site Web.

Changements au programme

Lunch des chefs de départements : Le lunch prévu pour les chefs de départements ce n'est pas encore confirmé car le CRM organise une réunion des chefs le 20 au 21 novembre 1999.

Histoire des mathématiques : Voici la liste des conférenciers invités: Tom Archibald (Acadia), Edward Barbeau (Toronto), Len Berggren (Simon Fraser), Louis Charbonneau (UQAM), Chongs Suh Chun (Athabasca), Florin Diacu (Victoria), Hardy Grant (Carleton), Minoru Hasegawa (Lakehead), Jacques Lefebvre (UQAM), Gregory Moore (McMaster), Richard O'Lander (St. John's University, USA), Dana Schlomiuk (Montreal), Ronald Sklar (St. John's University, USA), Viena Stastna (Calgary), George Styan (McGill), et Peter Zvengrow (Calgary).

Remerciements

Nous remercions les organisations suivantes pour leur soutien financier
- Centre de recherches mathématiques
- Institut des sciences mathématiques
- Réseau de calcul et de modélisation mathématique
- Laboratoire de combinatoire et d'informatique mathématique
- The Fields Institute for Research in Mathematical Sciences
- The Pacific Institute for the Mathematical Sciences

La SMC tient à remercier tous les membres du comité de coordination pour l'organisation de la réunion et des activités scientifiques, éducationelles et sociales.

Comité de Coordination

Président et coordinateur : Michel Delfour (Montréal)
Présidente du Comité local : Véronique Hussin (Montréal).
François Bergeron, Nantel Bergeron, George Bluman, Monique Bouchard (SMC ex-officio), Martin Goldstein, Michel Grundland, Lucien Haddad, Pierre Hansen, Joel Hillel, Jacques Hurtubise (SMC ex-officio), Jacqueline Klasa, François Lalonde, Gilbert Laporte, Benoît Larose, Sabin Lessard, Paul Libbrecht, Wendy MacCaull, Thomas Mattman, Angelo Mingarelli, Richard O'Lander, Ivo Rosenberg, Christiane Rousseau, David Sankoff, Phil Scott, Ronald Sklar, Gordon Slade, Graham Wright (SMC ex-officio), Mike Zabrocki.

Documents publiés avec cette annonce

Horaire et programme

Dans le prochain numéro des *Notes de la SMC*

Quatrième annonce
Horaire et programme à jour

SYMPOSIUM ON THE LEGACY OF JOHN CHARLES FIELDS: A Canadian Contribution to World Mathematical Year 2000

Background

The United Nations Educational Scientific and Cultural Organization (UNESCO) and the International Mathematical Union (IMU) have declared the year 2000 to be World Mathematical Year (WMY-2000). Countries around the world will be celebrating achievements in mathematics, in support of the three declared aims of WMY-2000:

The Three Aims of World Mathematical Year 2000:

- Meeting the great challenges of the 21st century
- Promoting mathematics as a key for development
- Raising the public image of mathematics

Across Canada, activities are being planned which will integrate these three aims of WMY-2000. These activities will raise awareness of Canadian achievements in mathematics and inspire young Canadians to pursue higher studies in mathematics,

which will qualify them for rewarding careers in the new millennium. A centerpiece of these Canadian celebrations is a world-class Symposium, organized by the Fields Institute, which will stir pride in our unsung Canadian hero in mathematics: John Charles Fields.

The Legacy of John Charles Fields

All Canadians have a right to be proud of Canada's contributions to the world of mathematics. This project will raise awareness of the Canadian visionary John Charles Fields and his exceptional legacy to the world of mathematics. In addition to being one of the original research mathematicians in Canada, he established the world's highest award for achievement in mathematics, now known internationally as the Fields Medal. It is often called the "Nobel Prize of Mathematics", since Nobel did not establish a prize for mathematics, but it has the same high standard of excellence. Four Fields Medals are awarded at each International Mathematical Congress, held at four year intervals (most recently in Berlin 1998, the next in Beijing 2002). The Fields Medal is struck by the Canadian Mint, of Canadian gold, and shows the head of the ancient Greek mathematician Archimedes on the face.

In the movie **Good Will Hunting**, *Robin Williams' character explains that his friend the MIT Professor has won the Fields Medal the highest award for achievement in mathematics. Many viewers assume that this award was invented for the story line. Very few are aware of the Canadian origins of the Fields Medal.*

An International Symposium of Fields Medallists

A Symposium on the Legacy of John Charles Fields will be held at the Royal Ontario Museum in Toronto, June 8-9, 2000, in celebration of WMY–2000. This is the first time a Symposium of Fields Medallists has been attempted, anywhere. It will bring together some of this century's leading thinkers to explain their medal-winning work and its impact on our world. The Fields Medallists will include: P-L. Lions (Paris), Vaughan Jones (Berkeley), Alain Connes (France), David Mumford (Harvard), Sir Michael Atiyah (Oxford/Edinburg), Stephen Smale (Berkeley/Hong Kong) and others to be confirmed. The program will feature public lectures of interest to teachers and students of mathematics. The high quality of this event will attract other leading mathematicians from abroad. It has received the IMU imprimatur as an official WMY– 2000 event, and it is listed in their official newsletter and web-site. This Symposium will have a high profile, with extensive media coverage which will raise public awareness of mathematics and its significance.

Highlights of the Symposium on the Legacy of John Charles Fields

- The Banquet Address will be given by Sir Michael Atiyah, the only person with both a Fields Medal and a knighthood.
- A documentary video, for television or schools, is planned on the life and times of John Charles Fields, his legacy and its impact through the work of the Fields Medallists.
- The Symposium will include both scientific and public lectures by Fields Medallists and an historical lecture on the life and times of John Charles Fields.
- The Symposium is closely coordinated with the JMATH 2000 Meeting, June 10-13, 2000 in Hamilton, which will bring together for the first time the Canadian Mathematical Society, the Canadian Applied and Industrial Mathematics Society, plus four other important Canadian conferences in the mathematical sciences.
- The Fields Medallists will be encouraged to extend their stay in Canada before or after the Symposium, to visit and work with leading Canadian researchers.
- Sponsors are being sought to award Visiting Fellowships to talented young mathematicians from third world countries so they can join this Canadian celebration, meet and work with Canadian and international mathematicians, and take new insights home with them.
- The Symposium is being coordinated with other Canadian WMY-2000 activities, including classroom projects and museum events.

3rd EUROPEAN CONGRESS OF MATHEMATICS

Barcelona 10–14 July 2000

FIRST ANNOUNCEMENT

The organizing committee is pleased to announce that the Third European Congress of Mathematics will take place from Monday 10 through Friday 14 July 2000. It is organised by the Societat Catalana de Matemàtiques, under the auspices of the European Mathematical Society.

PLENARY SPEAKERS

Robbert Dijkgraaf (Universiteit van Amsterdam, NL)
Hans Föllmer (Humboldt-Universität zu Berlin, DE)
Hendrik W. Lenstra, Jr. (University of California at Berkeley, USA, and Universiteit Leiden, NL)
Yuri I. Manin (Max-Planck-Institut für Mathematik, Bonn, DE)
Yves Meyer (École Normale Supérieure de Cachan, FR)
Carles Simó (Universitat de Barcelona, ES)
Marie-France Vignéras (Université de Paris 7, FR)
Oleg Viro (Uppsala Universitet, SE, and POMI St. Petersburg, RU)
Andrew J. Wiles (Princeton University, USA)

SCIENTIFIC PROGRAMME

The programme of the Congress includes nine plenary lectures, thirty invited lectures in parallel sessions, lectures given by the EMS prize winners, mini-symposia, round table discussions, and poster sessions. As in previous European Congresses, a number of prizes will be awarded to mathematicians under the age of 32. Mini-symposia are a new feature of the 3ecm; several current, interdisciplinary topics will be selected by the Scientific Committee. Short communications by participants will be possible in the form of posters. Demonstrations of mathematical software, video and multimedia are also planned.

COMMITTEES

The Scientific Committee is chaired by Sir Michael Atiyah (University of Edinburgh, GB).
The Prize Committee is chaired by Jacques-Louis Lions (Collège de France, FR).
The Round Table Committee is chaired by Miguel de Guzmán (Universidad Complutense de Madrid, ES).
The Organizing Committee is chaired by Sebastià Xambó Descamps (Universitat Politècnica de Catalunya, ES).

PRE-REGISTRATION

To receive the Second Announcement and information about the 3ecm by e-mail, please pre-register via the one of the following:

Societat Catalana de Matemàtiques,
Institut d'Estudis Catalans,
Carrer del Carme, 47, E-08001 Bacelona
tel: +34 93 270 1620
fax: +34 93 270 1180
e-mail: 3ecm@iec.es
web site: http://www.iec.es/3ecm or http://www.si.upc.es/3ecm/

Editor's Note: The balance of the First Announcement may be found at the Congress web site.

DRAFT Pending approval

MINUTES OF THE ANNUAL GENERAL MEETING

Memorial University of Newfoundland
St. John's, Newfoundland
May 30, 1999

The meeting opened at 4:00 p.m. with 30 members in attendance.

1. Adoption of the agenda

The agenda was adopted, with the addition of the following item:

- Under Other Business, the CUMC will be discussed.

2. Minutes of the previous meeting

G–99–1 MOTION (Hyndman/Williams)

That the minutes of the General Meeting, held December 13, 1998 at the Holiday Inn Kingston Waterfront, Kingston, Ontario, be accepted. *Carried Unanimously*

3. Matters Arising

There were no matters arising from the minutes.

4. President's Report

Kane announced that the first Endowment Grants Competition will take place in the fall of 1999, with at least $30,000 of funding. Under normal conditions, grants would be a maximum of $5,000.

Robert Quackenbush of the University of Manitoba has been appointed Managing Editor for the Society for a three-year term, beginning July 1, 1999. The revised job description for the Executive Director focuses more on development and fund raising.

Kane reported that the Government Policy Committee had

been dissolved and its tasks redistributed. He also reported on the establishment of the new Student Committee.

Task Forces and Review Committees continue their consultations. The final task force will focus on Office Strategies for the Executive Office.

Everyone is invited to participate in the Math 2000 activities, specifically the two CMS meetings being held in Hamilton in June and Vancouver in December. To reflect the special nature of the event, the June meeting has been named "Math 2000".

5. Nominating Committee Report

Wright presented the Tellers' Report. He proposed a vote of thanks to all the outgoing members of the Executive and Board of Directors.

G–99–2 MOTION (Nominating Committee)

That the Tellers' Report for the 1999 Election be accepted. *Carried Unanimously*

6. Treasurer's Report

Sherk presented the Treasurer's Report and noted that there was a good surplus. There was some discussion regarding whether the required financial statements could be produced by a Certified General Accountant, as opposed to a Chartered Accountant.

G–99–3 MOTION (Board of Directors)

That the Audited Statement for the financial year ended December 31, 1998 be accepted. *Carried Unanimously*

G–99-4 (Board of Directors)

That the Treasurer's Report for the financial year ended December 31, 1998 be accepted. *Carried Unanimously*

G–99–5 MOTION (Board of Directors)

That the firm of Raymond Chabot Grant Thornton be appointed as auditors for the financial year ending December 31, 1999. *Carried Unanimously*

The market value of the investments has now reached the level of $1,500,000 and this makes the new Endowment Grants Competition possible.

7. Executive Director and Secretary's Report

Wright announced that the Executive Office would be closed for two weeks in August.

8. Reports from Committees

G–99–6 MOTION (Board of Directors)

That the Annual Report to the Members be accepted, as amended. *Carried Unanimously*

Education Committee: The 1998 activities are described in the Annual Report to Members. Orzech expanded on Education Committee activities and initiatives since the last report to the members.

The CMS adjudicated and presented three prizes at the Canada Wide Science Fair held in Edmonton this May.

The education session at this meeting not only presented a slate of excellent talks but was very successful in drawing a sizeable complement of school teachers.

As an outcome of its deliberations at the current meeting, the Education Committee will recommend to the CMS Executive that the CMS appoint a Camel Education Page Editor. The Committee is also working on creating a registry of education speakers to be a resource in planning math education activities, including CMS and outreach activities. Further, the Committee will convey to the membership, at a later date, the name of recipient of the 1999 Adrien Pouliot award.

Electronic Services Committee: David Bates visited the Committee to consult for the Task Force on Finances and Fund Raising. Goodaire reported that Camel might serve as a conduit between students looking for goods and companies. He was looking for input.

Loki Jörgenson, the Camel Director, is heading up a revision of the Camel site. Many improvements are planned.

Finance Committee: The Finance Committee was very pleased to see the CMS reach the goal set for the beginning of the Endowment Grants Programme. Regarding investments, the CMS has adopted a passive management approach. Investments have been moved to Toronto Dominion Quantitative Capital.

Fund Raising Committee: The Committee is overseeing three campaigns. The first focuses on government sponsorship. Last year, 8 ministries provided funds. The second campaign focuses on corporate sponsorships. Wright has devoted much time on this, with good results. Of special note here is the new partnership with Imperial Oil on the math camps. The third campaign focus on membership. The AMS reciprocity agreement is being implemented in 2000 and will no doubt be at the center of the 2000 campaign. Initiatives to attract new membership include offering two-year free membership to new faculty members. Chairs will be asked to nominate new faculty members.

Human Rights Committee: The Board recently approved a Statement on the Employment of Young Mathematicians. This will be circulated to departments and faculty associations.

International Affairs Committee: There was no report from this Committee.

Mathematical Olympiads Committee: The Committee oversees several competitions. The details on this year's COMC were reported at the December meetings. Tingley reported that the 1999 CMO was written by 81 students in late April. Next year, the CMO will be housed at Simon Fraser University.

Tingley announced the 1999 IMO team. This year's IMO will be held in Romania in July.

The Correspondence Programme continues to be coordinated by Ed Barbeau.

In 1998 a National Math Camp was held in Waterloo in June. This year, a similar one will be organized by Tom Griffiths, Peter Crippin and Richard Hoshino.

Several regional camps are being held across the country. Next year, as part of the 2000 activities, it is hoped to expand this to even more sites.

Corporate participation in the Olympiads programme is increasing steadily. Sun Life has been a long standing contributor and has recently increased its donation significantly. Imperial Oil has now become the Title Sponsor for the Esso Math Camps. Tingley invited members to review the materials on Camel.

Nominating Committee: The Committee was pleased to announced that members had been appointed to the newly established Endowment Grants Committee and Student Committee. Other upcoming positions are being considered by the Committee.

Publications Committee: The Committee confirmed the appointment of Robert Quackenbush as the new Managing Editor. The work on transferring the Advanced Book Series from Wiley to Springer is almost complete. The work on the interior redesign of the journals is now complete and the production schedules are almost back on track.

The AMS has asked the CMS to change the direction of the Conference Proceedings Series. The Publications Committee is considering this matter.

Research Committee: Kane announced the sites of the future semi-annual meetings for the next three years.

Women in Mathematics Committee: Hyndman reported that the Committee continues to increase the number of sites on Camel. The Directory of Women in Mathematics now includes 58 names and she encouraged organizers to refer to it when seeking speakers.

A poster is being designed to present the Krieger-Nelson winners.

Student Committee: Charbonneau reported that the CUMC was held directly preceding this meeting and he encouraged departments to get their students involved. The new Student Committee will be trying to inform the students across Canada of what is available to them and to help them not feel isolated.

A new web page is being developed but current information on CUMC is available at www.cumc.math.ca. The Student Committee is looking for a webmaster and invited suggestions.

It was suggested that Camel might include a directory of graduating students.

At the Math 2000 meeting, the CUMC programme and the CMS programme will provide more information so that members of the CMS might attend CUMC talks. The conference poster will also be distributed on a wider basis.

9. Other Business

Ed Barbeau made a plea for articles for the Education Section of the Notes.

G–99–7 MOTION (Wright/Charbonneau)

That the Annual General Meeting express a special vote of thanks to Katherine Heinrich for her tireless work during her six years on the Executive Committee.
Carried Unanimously

10. Adjournment

The meeting adjourned at 5:20 p.m.

COMMITTEES AT WORK

ICMI Update

Peter Fillmore, Dalhousie University
Chair, International Affairs Committee

The recent appearance of ICMI Bulletin No.46 (June 1999) provides an opportunity to remind readers of the important work ICMI is doing and of Canadian involvement in that work. Further information on topics touched on in this report may be found at http://elib.zib.de/imu/icmi/bulletin/, which contains the complete text of the Bulletin.

What is ICMI? The International Commission on Mathematical Instruction is the arm of the IMU (International Mathematical Union) that is concerned with matters educational. A new executive committee was elected at the IMU General Assembly in August 1998, including Hyman Bass (Columbia) as president and Bernard Hodgson (Laval) as secretary. This means in particular that the Secretariat is now located at Laval University, where for example the ICMI Bulletin will be edited and produced for the next four years. Canada's new representative to ICMI is Eric Muller (Brock).

What does ICMI do? Its most important activities are the International Congresses on Mathematical Education (ICME) and the ICMI Studies. The congresses are held at four-year intervals, between the International Congresses of Mathematicians (ICM). The next, ICME-9, will take place July 31 to August 6, 2000, at the Nippon Conference Centre, near Tokyo. The first announcement is available at http://www.ma.kagu.sut.ac.jp/icmi9/ or by e-mail from icmi9@ma.kagu.sut.ac.jp. Readers may recall that a very successful earlier congress, ICME-7, was held at Laval and chaired by Bernard Hodgson.

Nine ICMI studies have been completed and a further three are in progress. A typical study consists of a study

conference followed by a study volume. The volumes are published by Kluwer, the most recent being [*Perspectives on the Teaching of Geometry for the 21st Century] (1998). A new study was recently launched, on the topic* The Future of the Teaching and Learning of Algebra].

Other ICMI activities include four affiliated study groups (history, women, psychology and competitions) and the Solidarity Programme (to assist the development of mathematics education in countries where there is a need that justifies international assistance).

CALL FOR NOMINATIONS / APPEL DE CANDIDATURES

Editors-in-Chief - Canadian Mathematical Bulletin

Rédacteurs-en-chef - Bulletin canadien de mathématiques

The term of office of the present Editors-in-Chief of the Candian Mathematical Bulletin will end December 31, 2000. The Publications Committee of the CMS now invites nominations for the next Editors-in-Chief to serve a five year term.

Applications should consist of a formal letter of application and include the following:

- A curriculum vitae
- An expression of views of the publication indicating if any changes in direction or policy are contemplated
- Since editorial responsibilities often necessitate a lessening of responsabilities in an individual's normal work, applicants should indicate that they have the support of their university department and, in particular, of their head of department.

The Publications Committee will communicate its recommendation to the Executive Committee of the CMS in April 2000. Any input from the mathematical community concerning this important selection process is welcome.

Applications (with supporting material) and/or comments should be sent to the address below. The deadline for the receipt of applications is **November 15, 1999**.

Le mandat des rédacteurs-en-chef actuels du Bulletin canadien de mathématique prendra fin le 31 décembre 2000. Le Comité des publications de la SMC sollicite des mises en candidatures pour les prochains rédacteurs-en-chef pour un mandat de cinq ans.

Les mises en candidature doivent inclure une lettre formelle et les éléments suivants:

- Un curriculum vitae
- L'expression de votre opinion sur la publication indiquant si des changements de directions ou de politiques sont envisagés
- Puisque les responsabilités de rédaction nécessitent souvent une réduction dans la charge normale de travail, les candidats devraient indiquer qu'ils(elles) ont l'appui de leur département et en particulier, de leur chef de department.

Le Comité des publications transmettra ses recommandations au Comité exécutif de la SMC en avril 2000. Les commentaires de la communauté mathématique au sujet de cette importante sélection sont bienvenus.

Les mises en candiatures (avec matérial à l'appui) et/ou commentaires devraient être acheminés à l'adresse ci-dessous. L'échéance pour la réception des mises en candidature est le **15 novembre 1999.**

Editors-in-Chief - CMS Notes / Rédacteurs-en-chef - Notes de la SMC

The term of office of the present Editors-in-Chief of the *CMS Notes*will end December 31, 2000. The Publications Committee of the CMS invites applications for the next Editor(s)-in-Chief to serve for a five year term.

Applications should consist of a formal letter of application with curriculum vitae.

The Publications Committee will communicate its recommendation to the Executive Committee of the CMS in April 2000. Applications and/or comments should be sent, by **November 15,1999** to the address below.

Le mandat du rédacteurs-en-chef actuels des *Notes de la SMC* prendra fin le 31 décembre 2000. Le Comité des publications de la SMC sollicite les mises en candidature pour le prochain rédacteurs-en-chef pour un mandat de cinq ans.

Les mises en candidature doivent inclure une lettre formelle ave curriculum vitae.

Le Comité des publications transmettra ses recommendation au Comité exécutif de la SMC en avril 2000. Les candidatures et/ou commentaires devraient être acheminés, avant **le 15 Novembre 1999** à l'adresse ci-dessous.

Address for Nominations / Addresse de mise en candidatures:

James A. Mingo
Chair / Président
CMS Publications Committee / Comité des publications de la SMC
Department of Mathematics and Statistics
Queen's University
Kingston, Ontario K7L 3N6

THE INSTITUT DES SCIENCES MATHÉMATIQUES ET LE CENTRE DE RECHERCHES MATHÉMATIQUES JOINT POST DOCTORAL FELLOWSHIP / BOURSES POSTDOCTORAL CRM-ISM

The Institut des sciences mathématiques (ISM) and the Centre de recherches mathématiques (CRM) are inviting applications for their joint postdoctoral fellowship program starting in approximately September 2000. The annual stipend is Cdn. $32, 000 for one year, renewable for a second year.

The ISM coordinates the graduate programs of six Québec universities (Concordia, Laval, McGill, Sherbrooke, Université de Montréal and UQAM). More than 200 faculty members participate in its ten programs: Algebra and Number Theory, Analysis, Combinatorics, Algebraic Computation and Algorithms, Nonlinear Dynamics, Geometry and Topology, Applied and Computational Mathematics, Mathematical Physics, Probability: Theory and Applications, Decision Theory and Mathematical Statistics, and Category Theory and Applications.

The CRM is a national research center in the mathematical sciences. Its ongoing areas of research include: algebra and combinatorics, analysis, differential equations and approximation theory, geometry and topology, numerical analysis, optimisation and multidisciplinary research, mathematical physics, probability and statistics, and dynamical systems. Each year, the CRM organizes a wide range of events attracting participants from around the world. The main themes for 2000-2001 are Mathematical Methods in Biology and Medicine, and Symplectic Geometry and Topology and Gauge Theory. In 2001-2002 the main themes will be Groups and Geometry. However, high-quality applications in all fields of interest to the CRM or to the ISM are welcome.

Applications must arrive at the ISM by **Friday, January 7, 2000.** The following documents are required: a curriculum vitae, a statement of research, and three letters of recommendation. Please indicate in your application which ISM program best represents your research interests. An e-mail address and fax number (if available) must be provided with all correspondence. Candidates are encouraged to contact the professors with whom they would like to work.

Applications must be sent to the address given below:

L'Institut des sciences mathématiques (ISM) et le Centre de recherches mathématiques (CRM) sollicitent des candidatures dans le cadre de leur programme conjoint de bourses postdoctorales débutant approximativement en septembre 2000. Les bourses sont d'une valeur de 32 000 $ CAN pour un an, renouvelables pour une deuxième année.

L'ISM coordonne les programmes d'études supérieures de six des universités québécoises (Concordia, Laval, McGill, Sherbrooke, Université de Montréal et UQAM). Plus de 200 professeurs et professeures participent à ses dix programmes: Algèbre et théorie des nombres, Analyse, Combinatoire et calcul algébrique, Dynamique non linéaire, Géométrie et topologie, Mathématiques appliquées et calcul scientifique, Physique mathématique, Probabilités: théorie et applications, Théorie de la décision et statistique, et Théorie des catégories et applications.

Le CRM est un centre national de recherche en sciences mathématiques. Les recherches qu'on y poursuit portent entre autres sur les domaines suivants: l'algèbre et la combinatoire, l'analyse, les équations différentielles et la théorie de l'approximation, la géométrie et la topologie, l'analyse numérique, l'optimisation et les recherches multidisciplinaires, la physique mathématique, les probabilités et la statistique, et les systèmes dynamiques. Le CRM organise annuellement un large éventail d'activités scientifiques impliquant une participation internationale. Les thèmes principaux de l'année 2000-2001 seront d'une part les méthodes mathématiques en biologie et en médicine et d'autre part la topologie et la géométrie symplectiques ainsi que la théorie de jauge. Les thèmes de l'année 2001-2002 porteront sur les groupes et la géométrie. Cependant, toute candidature méritoire touchant à un domaine d'intérêt du CRM ou de l'ISM sera bienvenue.

Les candidatures doivent parvenir à l'ISM (adresse ci-dessous) au plus tard **le vendredi 7 janvier 2000.** Les documents suivants doivent être joints: un curriculum vitae, un résumé des intérêts de recherche, et trois lettres de recommandation. Vous êtes prié d'indiquer sur votre demande lequel des programmes de l'ISM représente le mieux vos intérets de recherche. Une adresse électronique et un numéro de télécopieur (si disponible) doivent être inclus avec toute correspondance. Les personnes intéressées sont encouragées à contacter les professeurs avec qui elles aimeraient travailler. Les candidatures doivent être envoyées à:

Professor François Lalonde, Director / Directeur
Institut des sciences mathématiques
Case postale 8888, Succursale Centre-Ville
Montréal (Québec), Canada, H3C 3P8
Fax / Télécopieur : (514) 987-8935 E-mail / Courrier électronique : ism@math.ca

UNIVERSITY OF TORONTO – TORONTO, ONTARIO
DEPARTMENT OF MATHEMATICS
Tenure-Stream Appointment in Algebra, Number Theory and Geometry

The University of Toronto solicits applications for a tenure-stream appointment in the fields of Algebra, Number Theory and Geometry. Preference will be given to researchers in arithmetic geometry.

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2000. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to Mathematics. Salary commensurate with experience.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/

To ensure full consideration, this information should be received by **December 1, 1999.**

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples and persons with disabilities.

UNIVERSITY OF TORONTO – TORONTO, ONTARIO
DEPARTMENT OF MATHEMATICS
Tenure-Stream Appointment in Applied Mathematics

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment for a mathematician working in the area of Applied Mathematics.

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2000. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics. Salary commensurate with experience.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/

To ensure full consideration, this information should be received **by December 1, 1999.**

In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples and persons with disabilities.

UNIVERSITY OF TORONTO – TORONTO, ONTARIO
DEPARTMENT OF MATHEMATICS
Tenure-Stream Appointment in Applied Mathematics – Computational Science

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment for a mathematician working in the area of Applied Mathematics (Computational Science).

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2000. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics. Salary commensurate with experience.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/

To ensure full consideration, this information should be received **by December 1, 1999.**

In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples and persons with disabilities.

UNIVERSITY OF TORONTO – TORONTO, ONTARIO
DEPARTMENT OF MATHEMATICS
Limited Term Assistant Professorships

The Department invites applications for one or more limited term Assistant Professorships which may, subject to budgetary approval, become available at the St. George (downtown), Scarborough or Erindale campus, for a period of one to three years, beginning July 1, 2000. Duties consist of teaching and research, and candidates must demonstrate clear strength in both. Preference will be given to candidates with recent doctoral degrees. Salaries commensurate with qualifications.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least three letters of reference sent directly to:

Search Committee
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Canada M5S 3G3

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available on our World Wide Web Employment Opportunities page: http://www.math.toronto.edu/jobs/

To ensure full consideration, all information should be received **by December 1, 1999.**

Further information about academic positions in the Department of Mathematics is available on the World Wide Web by accessing the above URL.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples and persons with disabilities.

UNIVERSITY OF TORONTO – SCARBOROUGH, ONTARIO
PHYSICAL SCIENCES DIVISION
Tenure-Stream Appointment in Mathematics

The Physical Sciences Division, University of Toronto at Scarborough invites applications for a tenure-stream appointment in Mathematics. Preference will be given to candidates with interests in the areas of Analysis or Applied Mathematics.

The appointment will be at the level of Assistant Professor, effective on or after July 1, 2000. The successful candidate will be cross-appointed to the graduate Department of Mathematics, University of Toronto, on the downtown (St. George) Campus.

Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics. Salary commensurate with experience.

Applicants should send their complete C.V. including a list of publications, a short statement describing their proposed research programme, and all appropriate material about their teaching background. Applicants should also arrange for at least four letters of reference, including at least one primarily concerned with the candidate's teaching abilities and experience.

All correspondence should be sent to:
Professor J.C. Thompson
Chair, Physical Sciences Division
University of Toronto at Scarborough
1264 Military Trail
Scarborough, Ontario
M1C 1A4

In addition, it is recommended that applicants submit the electronic application form at http://www.math.utoronto.ca/jobs/.

Candidates who apply also for other appointments with the Department of Mathematics, University of Toronto need only submit one application to that Department but should indicate clearly that they wish to be considered for this appointment as well.

To ensure full consideration, this information should be received **by December 1, 1999.**

Any inquiries about applications should be addressed to:
Professor R.-O. Buchweitz
Associate Chair Hiring
Department of Mathematics
University of Toronto
100 St. George Street, Room 4072
Toronto, Ontario M5S 3G3

In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and to permanent residents of Canada. In accordance with its Employment Equity Policy, the University of Toronto encourages applications from qualified women or men, members of visible minorities, aboriginal peoples and persons with disabilities.

CMS MEMBERSHIP ...

The 2000 Membership Notices have been mailed. Don't forget to renew your membership.

ADHÉSION À LA SMC ...

Les avis d'adhésion 2000 était postés. N'oubliez pas de renouveller votre adhésion.

UNIVERSITÉ McGILL UNIVERSITY – MONTRÉAL, QUÉBEC
DEPARTMENT OF MATHEMATICS AND STATISTICS
DÉPARTEMENT DE MATHÉMATIQUES ET DE STATISTIQUES

The Department of Mathematics and Statistics of McGill University invites applications for a tenure track position in statistics at the assistant professor level.

A Ph.D. degree in statistical science is essential. Preferred areas of specialization are computational statistics, sample surveys and time series analysis, although not exclusively so. Preference will be given to applicants with a strong theoretical background in statistics, whose work is driven by applications.

The appointment is to begin July 1, 2000.

Applicants are expected to have demonstrated the capacity for independent research of excellent quality. Selection criteria include research accomplishments, as well as potential contributions to the research interests of the Department and to its educational programs at both the undergraduate and graduate levels.

Applications, with a curriculum vitae, a list of publications, a research proposal, an account of teaching experience and the names, phone numbers and e-mail addresses of at least four references (with one addressing the teaching record) should be sent to:

Professor K. GowriSankaran, Chair
Department of Mathematics and Statistics
McGill University
805 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2K6

Candidates must arrange to have the letters of recommendation sent directly to the above address. Candidates are also encouraged to include copies of up to 3 selected publications with their application.

To ensure full consideration, applications must be received by **November 30, 1999,** although the search will continue until the position is filled.

McGill University is committed to equity in employment and in accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Le département de mathématiques et de statistique de l'Université McGill cherche à pourvoir un poste en statistiques au niveau de professeur adjoint, menant à la permanence.

Un doctorat en statistique est essentiel. Les domaines prioritaires sont l'échantillonnage, la statistique informatique ou l'analyse des séries chronologiques; ces priorités ne sont pas exclusives. La préference sera accordée aux candidats ayant une forte formation théorique en statistiques et dont les travaux sont motivés par des applications.

La date d'entrée en fonction sera le premier juillet 2000.

Les candidats devront avoir démontré leur capacité de mener à bien une recherche indépendante et de haut niveau. Parmi les critères de sélection des candidats figurent leurs réalisations en recherche, ainsi que leurs contributions potentielles aux activités de recherche du département et à ses programmes d'enseignement à tous les cycles.

Les demandes, comprenant un curriculum vitae, une liste de publications, un aperçu des projets de recherches, une description de l'expérience acquise en enseignement et les noms, numéros de téléphone et adresses electroniques d'au moins quatre répondants (dont un pourra commenter les qualités d' enseignant du candidat) doivent être envoyées à :

Professeur K. GowriSankaran, Directeur
Département de mathemátiques et statistique
Université McGill
805, rue Sherbrooke ouest
Montréal (Québec) Canada H3A 2K6

Les candidats doivent demander à leurs répondants d'envoyer leurs lettres de recommandation directement á l'adresse ci-dessus. Ils sont également invités á inclure en annexe á leur demande des copies de trois de leurs publications au plus.

Pour être prises pleinement en considération, les demandes devront être reçues **le 30 novembre 1999** au plus tard. Les recherches se poursuivront jusqu'a ce que le poste soit comblé.

L'Université McGill souscrit a l'équité en matière d'emploi et, conformément à la législation canadienne en matière d'immigration, accorde la priorité aux citoyens canadiens et aux résidents permanents du Canada.

UNIVERSITÉ McGILL UNIVERSITY – MONTRÉAL, QUÉBEC
DEPARTMENT OF MATHEMATICS AND STATISTICS
DÉPARTEMENT DE MATHÉMATIQUES ET DE STATISTIQUES

Consultant en statistique / Statistical Consultant

Le département de mathématiques et statistique de l'Université McGill est à la recherche d'un consultant pour co-gérer son nouveau service de consultation statistique (SCS). Dans un premier temps ce poste est prévu pour une période de trois ans. L'entrée en fonction est prévue le 1er janvier 2000.
Titre : Chargé d'enseignement
Fonctions : S'occuper, avec un autre consultant du Centre de calcul de McGill, de l'exploitation quotidienne du service de consultation statistique (SCS), sous la supervision du directeur du service. Animer des séances d'information sur le campus sur les services offerts par le SCS. Offrir des consultations aux professeurs et étudiants et exécuter des analyses statistiques, rédiger des rapports et collaborer à la rédaction des demandes de subvention et autres projets de recherche. Administrer la facturation des services. Donner au moins un cours de statistique de 1er cycle par an. Participer à l'organisation d'un cours de consultation statistique au niveau des 2e/3e cycles. Aider les étudiants de 2e/3e cycle en statistique dans leur thèse ou projet, au besoin. Animer à l'occasion des ateliers sur les logiciels et les statistiques appliquées. Lire les publications sur les statistiques, participer à des conferences scientifiques de manière à pouvoir offrir des conseils à jour à l'ensemble de la clientèle.
Qualifications : Maˆen statistique est impérative. Au moins deux ans d'expérience dans un poste de statisticien appliqué ou d'analyste de données. Connaissance des logiciels statistiques standards, des méthodes multivariées et univariées paramétriques et non paramétriques. La connaissance de la méthode des séries chronologiques est un atout. Bon sens de la communication orale et écrite et des relations interpersonnelles.
Date limite : Veuillez faire parvenir votre candidature avant le **1er novembre 1999.** La sélection se poursuivra néanmoins jusqu'à ce que le poste soit pourvu. Les candidats doivent demander à trois répondants d'envoyer leurs lettres de recommandation directement à l'adresse ci-dessous.

Veuillez faire parvenir votre candidature à :
Professeur K. GowriSankaran, Directeur
Département de mathématiques et statistique
Université McGill
805, rue Sherbrooke ouest
Montréal (Québec) Canada H3A 2K6
Courriel: chair@math.mcgill.ca

L'Université McGill souscrit a l'équité en matière d'emploi et, conformément à la législation canadienne en matière d'immigration, accorde la priorité aux citoyens canadiens et aux résidents permanents du Canada.

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Qualifications: A Master's degree in statistical science is essential. At least two years experience as an applied statistician and data analyst. Familiarity with the standard statistical software packages and with both parametric and nonparametric univariate and multivariate methods. Knowledge of time series methods an asset. Effective oral, written, communication, and interpersonal skills.
Deadline: For full consideration applications should be received by **November 1, 1999,** although the search will continue until the position is filled. Candidates must arrange for three letters of recommendation to be sent directly to the address below.

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Professor K. GowriSankaran, Chair
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McGill University
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CALENDAR OF EVENTS / CALENDRIER DES ÉVÉNEMENTS

OCTOBER 1999 **OCTOBRE 1999**

11–24 Workshops for Mathematics and its Applications (University of Minnesota, Minneapolis,MN)
http://www.ima.umn.edu/reactive/fall/msl.html

16–17 West Coast Operator Algebra Symposium (University of Victoria, Victoria, BC)
www.math.uvic.ca/ wcoas

NOVEMBER 1999 **NOVEMBRE 1999**

14–18 International Conference on Mathematics Education into the 21st Century (Cairo, Egypt)
Dr. A Rogerson: arogers@mgs.vic.edu.au

20–21 Canadian Department Chairs' Meeting, CRM, Montreal
bluman@math.ubc.ca

29–Dec. 3 Group Theory and Computation (University of Sydney, Australia)
http://math.auckland.ac.nz/conference/groups-11-1999

DECEMBER 1999 **DÉCEMBRE 1999**

2–5 The Future of Mathematical Communication, 1999, MSRI (Berkeley, California)
http://www.msri.org/activities/events/9900/fmc99/

11–13 CMS Winter Meeting / Réunion d'hiver de la SMC (Université de Montréal)
http://cms.math.ca/CMS/Events/

JANUARY 2000 **JANVIER 2000**

19–22 Joint Mathematics Meetings, including the 106th Annual Meeting of the AMS (Washington DC),
a WMY2000 event *www.ams.org/meetings/*

MARCH 2000 **MARS 2000**

6–10 Fourth International Conference on Operations Research (Havana, Cuba) *lorch@mathstat.yorku.ca*

MAY 2000 **MAI 2000**

5–7 Unified Congress of Mathematical Associations and Groups of Quebec (Université Laval), a WMY2000 event
pallascio.richard@uqam.ca

JUNE 2000 **JUIN 2000**

Canadian Mathematics Education Study Group Meeting (UQAM, Montreal) *Dates to be announced*

4–7 Annual Meeting of the Statistical Society of Canada (Ottawa, Ontario) *André Dabrowski: adrsg@uottawa.ca*

4–8 Canadian Annual Operator Algebra Symposium (Fields Institute, Toronto, Ontario) *elliott@math.utoronto.ca; choi@math.utoronto.ca*

8–9 Symposium on the Legacy of John Charles Fields (The Royal Ontario Museum, Toronto); a WMY2000 event
www.fields.utoronto.ca

10–13 MATH 2000 (McMaster University, Hamilton, Ontario)
Paticipating Societies include the Canadian Mathematical Society (CMS), the Canadian Applied and Industrial Mathematics Society (CAIMS), the Canadian Operational Research Society (CORS), the Canadian Symposium on Fluid Dynamics (CSFD), the Canadian Society for the History and Philosophy of Mathematics (CSHPM) and the Canadian Undergraduates Mathematics Conference (CUMC). A WMY2000 event
Monique Bouchard: meetings@cms.math.ca

12–15 Integral Methods in Science and Engineering (Banff, Alberta) *Peter.Schiavone@ualberta.ca*

JULY 2000 **JUILLET 2000**

10–14 Third European Congress of Mathematics (Tokyo/Makuhari)
www.ma.kagu.sut.ac.jp/ icme9/

11–25 41st International Mathematical Olympiad (Korea)

31–Aug 7 International Congression the Teaching of Mathematics ICME-9 (Barcelona, Spain)
3ecm@iec.es; http://www.si.upc.es/3ecm/

AUGUST 2000 **AOÛT 2000**

7–12 AMS Meeting (Los Angeles); a WMY2000 event
www.ams.org/meetings/

SEPTEMBER 2000 **SEPTEMBRE 2000**

22–24 American Mathematical Society Central Section Meetings (University of Toronto)
http://www.ams.org/meetings/

DECEMBER 2000 **DÉCEMBRE 2000**

10–12 CMS Winter Meeting / Réunion d'hiver de la SMC (University of British Columbia, Vancouver, B. C.)
Monique Bouchard: meetings@cms.math.ca

JUNE 2001 **JUIN 2001**

CMS Summer Meeting / Réunion d'été de la SMC (University of Saskatchewan, Saskatoon, Saskatchewan)
Monique Bouchard: meetings@cms.math.ca

Canadian Mathematics Education Study Group Meeting (University of Alberta, Edmonton)

Annual Meeting of the Statistical Society of Canada (Vancouver, British Columbia)

DECEMBER 2001 **DECEMBRE 2001**

CMS Winter Meeting / Réunion d'hiver de la SMC (York University, Toronto, Ontario)
Monique Bouchard: meetings@cms.math.ca

JUNE 2002 **JUIN 2002**

CMS Summer Meeting / Réunion d'été de la SMC (Université Laval, Québec, Québec)
Monique Bouchard: meetings@cms.math.ca

AUGUST 2002 **AOÛT 2002**

20–28 International Congress of Mathematicians, (Beijing, China)
cms@math08.math.ac.cn; http://icm2002.org.cn/

DECEMBER 2002 **DECEMBRE 2002**

CMS Winter Meeting / Réunion d'hiver de la SMC (University of Ottawa / Université d'Ottawa, Ottawa, Ontario)
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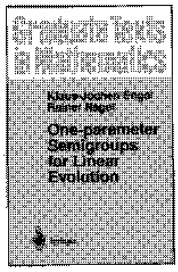

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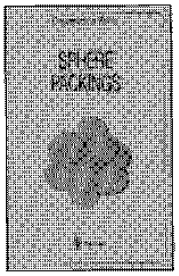
SPHERE PACKINGS



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