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PI/PD DEPARTMENT **Mathematical Sciences**	PI/PD POSTAL ADDRESS **Clemson, SC 296345702** **United States**
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CERTIFICATION PAGE

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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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(Indicate the most specific unit known, i.e. program, division, etc.)

DMS - COMPUTATIONAL MATHEMATICS

Project Summary

October 8, 2003

Since their introduction in 1965, Gröbner bases have played an important role in algebraic geometry and in multivariate polynomial system solving. Over the past ten years, applications of Gröbner bases have appeared in many diverse areas of scientific research, including such practical areas as cryptography, error-control coding, biological engineering and algebraic statistics.

This interdisciplinary flavor in the Grobner basis literature is due in large part to the development of e cient algorithms for computing Gröbner bases. Much of this improvement has centered around Grobner basis computations in the case of zero-dimensional ideals (those with finite solution space); all the applications mentioned above fit this description. Recently, we have added a new algorithm to this literature that significantly outperforms current methods in certain important situations.

The aim of this project is to further the interaction between the theory of Grobner bases and these important applied areas, particularly looking to exploit possible advances due to our recent improvement. We propose both applied and theoretical mathematical problems for our postdoctoral study. Suggested applied problems include implementation of our results in an actual computer algebra system, several detailed questions concerning algebraic decoding, a novel encoding method for the popular low density parity-check (LDPC) codes, and the exploration of uses in biological engineering and computational geometry. Proposed theoretical problems involve extending our results to apply to projective varieties and developing a modular version of our algorithm to enhance computing performance over rationals, as well as some side issues dealing with Sudan-Guruswami list decoding and a question in combinatorics.

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Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Project Description

October 8, 2003

1 Detailed Research Plan

My research plan involves the areas of symbolic computation and discrete mathematics. For the most part, the proposed research builds on work done for my doctoral thesis as well as work done earlier in my graduate career. We present both theoretical and applied problems. The applications we focus on demonstrate the interdisciplinary flavor of our work, touching such diverse fields as error-correcting codes, computational geometry and computational biology.

1.1 Problems in Symbolic Computation

Gröbner bases are at the heart of any computer algebra system, so efficient computing of Gröbner bases has been a very active research area [4, 8, 22] since the first algorithm was given by Buchberger in 1965 [3]. Of particular interest to us is the problem of computing a Gröbner basis for the (zero-dimensional) vanishing ideal of a finite set of affine points. That is, given a set of points $\{P_1, \ldots, P_n\} \subseteq \mathbb{F}^m$, where $\mathbb{F}$ is a field, find a Gröbner basis for the polynomial ideal $\mathbf{I}(V) = \{f \in \mathbb{F}[x_1, \ldots, x_m] : f(P_i) = 0, 1 \leq i \leq n\}$.

1.1.1 Implementation of a Gröbner basis algorithm

The first group of problems which I propose to study involves the problem of computing Gröbner bases. Recently, we have added to the literature for computing Gröbner bases for zero-dimensional ideals. In [10] we present the following theorem.

Theorem 1 *Suppose $G = \{g_1, \ldots, g_s\}$ is a Gröbner basis for $\mathbf{I}(V)$, for a finite set $V \subset \mathbb{F}^m$. For a point $P = (a_1, \ldots, a_m) \notin V$, let g_i denote the smallest polynomial in G such that $g_i(P) \neq 0$, and define*

$$\begin{aligned} \tilde{g}_j &:= g_j - \frac{g_j(P)}{g_i(P)} \cdot g_i, \qquad j \neq i, \text{ and} \\ g_{ik} &:= (x_k - a_k) \cdot g_i, \qquad 1 \leq k \leq m. \end{aligned}$$

Then

$$\widetilde{G} = \{\tilde{g}_1, \ldots, \tilde{g}_{i-1}, \tilde{g}_{i+1}, \ldots, \tilde{g}_s, g_{i1}, \ldots, g_{im}\}$$

is a Gröbner basis for $\mathbf{I}(V \cup \{P\})$.

Theorem 1 immediately implies an iterative polynomial-time algorithm that may be used to compute the reduced Gröbner basis of $\mathbf{I}(V)$. Also in [10] we compare the performance of this algorithm compared to two current methods–the linear algebra technique (any one of a number of variants of the Buchberger-Möller algorithm [4]) and a recent algorithm of Fitzpatrick and O'Keeffe [14]. This latter approach is similar to ours except that it does not compute the reduced Gröbner basis, and is, hence, exponential in the number of variables. Additionally, [10] introduces a preprocessing technique that significantly enhances all three of the algorithms mentioned.

The first research problem for the proposed postdoctoral fellowship, then, is to install both the algorithm and the preprocessing technique in a computer algebra system such as Maple, Magma or CoCoA. This research would involve convincing the chief designers of the systems that the project is worthwhile, as well as actually implementing the software. Since the algorithm is already designed and an early version of the code already exists in one system, though, the feasibility of this project is well within reach.

The second research problem is to develop a modular version of this new algorithm. This problem is closely connected to the first. The experiments in [10] were conducted only over finite fields. It is well-known that when working over the field of rationals, the efficiency of computing Gröbner bases suffers immensely due to exponential growth in the size of the coefficients in the intermediate calculations. To combat this problem, modular algorithms have been developed for other Gröbner basis methods [9, 2]. We believe that such a method is both necessary and achievable in our case.

The final proposed research problem that deals with practical issues arising from the implementation of our Gröbner basis algorithm involves the numerous computational issues that arise from nonexact arithmetic. The problem here is first in determining what numerical problems are important to our situation. For example, small perturbations might occur in the input or in intermediate computation. How does this affect the solution? It is unclear to us at this point whether the current literature has anything to say concerning these issues for algorithms, such as ours, which depend on long division of multivariate polynomials. Once the numerical problems are well-defined, we, of course, hope to provide solutions.

1.1.2 Projective Varieties

In [1] a variation of the Buchberger-Möller algorithm was introduced to handle the case in which projective rather than affine points are considered (see also [21]). In this case it is desirous to compute a Gröbner basis for the homogeneous vanishing ideal. A straightforward modification of our algorithm is possible to ensure that all the polynomials are homogeneous. Unfortunately, in some cases this modification results in the basis' failing to be Gröbner . The proposed research problem is to present an acceptable version of our algorithm to handle projective points.

1.1.3 Applications

Implicitization, the process of finding an implicit representation of a geometric design, is a technique that finds applications in areas such as computer-aided geometric design and solid modeling. The problem of finding an algorithm for implicitization that is both reliable (computes a correct answer) and efficient is nontrivial and of great interest. Recently, Tran [27] proposed a Gröbner basis method to find an implicit representation of a surface supposing a parametric representation is given. His method was more reliable than current methods, but not as efficient.

As our next research problem, we propose an alternate application of Gröbner bases to implicitization. Given a parametric representation of a surface, we can easily generate many points on the surface. If these points are scattered randomly across the surface, we hope that the Gröbner basis for the vanishing ideal of these points would contain an acceptable implicit representation of the curve. It is often the case that certain "problem spots" exist on the surface. In this case we could introduce extra points around these spots as needed. Since our algorithm is iterative, we would not have to redo previous computation to undertake such a refinement.

Low-density parity-check (LDPC) codes, first defined by Gallager in 1962, have experienced somewhat of a revival in the last five years. Through iterative decoding techniques, the performance of LDPC codes approaches the Shannon limit and, hence, rivals the performance of the popular turbo codes. Thus, a proper understanding of these codes is of great interest in the communication industry. The challenges associated with LDPC codes are, in a way, opposite of the problems typical to most practical codes. By design, decoding is extremely powerful and efficient, while the encoding of LDPC codes is a difficult problem. Until very recently, the best constructions of LDPC codes involved techniques from graph theory [20]. Currently, researchers are exploring algebraic or geometric constructions with hope that the additional structure will allow for efficient encoding [15]. We believe that a simple construction of LDPC codes is possible via the Gröbner basis methods we have developed, and we hope to realize the solution to this problem in our postdoctoral research.

Our final research problem involving the algorithm from [10] is to search for more applications which would benefit from our work. One research area that shows some promise is the rapidly growing field of algebraic statistics [23]. Certain problems in design of experiments, in particular, are already posed in a way to take advantage of our improvements [24]. Also, recent work by Laubenbacher and Stigler on genetic networks in biological engineering give hope that an application of our work would render larger, more realistic models computationally feasible [18].

1.1.4 Padé approximation

In [11] we consider the multivariate Padé approximation problem. That is, given a function f in m variables, find polynomials $a, b \in \mathbb{F}[x_1, \ldots, x_m]$ so that $f \equiv \frac{a}{b} \mod I$ for some fixed ideal I. Following the lead of Fitzpatrick and Flynn [13] and Little, *et al.* [19], we apply the method of Gröbner bases for modules to find a solution to the related problem $f \cdot b - a \equiv 0 \mod I$. Of course, any solution to the second problem is a solution to the first as long as $b(P) \neq 0$ for any point P in the variety of I.

Theorem 2 *Fix a monomial order on $\mathbb{F}[\mathbf{x}] = \mathbb{F}[x_1, \ldots, x_m]$, and let I be a zero-dimensional ideal with monomial basis*

$$\mathcal{B}(I) = \{1 = \mathbf{x}^{\alpha_1}, \mathbf{x}^{\alpha_2}, \ldots, \mathbf{x}^{\alpha_t}\}.$$

Define N and D to be the smallest t_1 and t_2 elements of $\mathcal{B}(I)$, respectively, where t_1 and t_2 are any positive integers so that $t_1 + t_2 = t + 1$. Then, for any $f \in \mathbb{F}[\mathbf{x}]$, there is a pair of polynomials a and b, not both zero, such that

$$a = \sum_{\mathbf{x}^i \in N} a_i \mathbf{x}^i; \qquad b = \sum_{\mathbf{x}^i \in D} b_i \mathbf{x}^i; \qquad \textit{and} \quad a \equiv f \cdot b \mod I. \tag{1}$$

Further, (a, b) is an element in the reduced Gröbner basis for the module $M_f = \{(g, h) : f \cdot h - g \in I\}$ under the $\prec_w$ term order defined in [11].

By choosing a clever term order for the module, our theorem is more flexible and powerful than the previous two. Also, computational results from [10] indicate that, at least for small m, this Gröbner basis method may compete favorably with the more standard linear algebra techniques for solving the multivariate Padé problem. Applications in analysis often require the Padé approximant to have certain properties. It may be possible to force some of these properties on our solution by choosing the ideal I carefully.

1.1.5 Algebraic decoding

In [12] we explore an important application of Padé approximation, namely the algebraic decoding of a large class of random linear error-correcting codes. Specifically, we describe a construction of a random (linear) affine variety code of blocklength n and dimension k. This construction includes the very important class of one-point algebraic geometry codes. In general, though, we know very little about the properties of the code, such as minimum distance or weight distribution. Despite our limited knowledge, we are still able to use the algorithm of [10] to find an error-locator polynomial, and, hence, decode the received vector to the correct codeword. To estimate the minimum distance of a given random code (or a collection of these codes), we introduce errors at a controlled rate until decoding failure occurs.

There are several questions related to these codes which we hope to explore during the postdoc. First, we need to properly interpret our decoding. In particular, we would like to compare the estimated minimum distance for a fixed code length to the good asymptotics (as $n \to \infty$) known for linear codes over a q-ary symmetric channel. Also, we would like to compare our decoding performance to the decoding performance for other "random" codes such as the LDPC codes mentioned above. It would also be possible to use our decoding method to search for new codes that perform well.

1.2 Problems in Discrete Mathematics

1.2.1 List Decoding

Sudan-Guruswami list decoding of Reed-Solomon and other algebraic geometry codes is a recent development [16] that has made a profound impact on the coding community and has even found applications in cryptography [25]. Since Reed-Solomon codes are powerful, widely-used codes, a flurry of research has ensued Sudan's first results in 1997 [26]. Rather than returning a single codeword, a list decoder returns a collection of codewords and is said to be successful if the collection contains the sent codeword. We say that a list decoder is strongly successful if the sent codeword is the closest codeword in the list to the received vector. In theory list decoding can correct many more errors than classical decoding methods; however, it is unknown how well list decoding performs if we require the decoder to be strongly successful. We propose to study this problem to determine on average the number of errors that a list decoder can strongly correct. This study would have ramifications on how feasible list decoding would be in practice. Also, this problem deals with the larger problem of the possibility of perfectly decoding algebraic geometry codes.

1.2.2 Combinatorics

In their analysis of a problem of Lampert and Slater [17], Calkin, Canfield and Wilf [5] considered the limiting behavior of a sequence of real numbers q_n in the interval $[0,1]$ defined by $q_0 = 0$, $q_1 = 1$, and, for $n \geq 2$, q_n equals a weighted average of preceding terms in the sequence. They proved that if the weights are sharply concentrated around a value αn, where α is fixed in $[0,1]$, and if this sequence oscillates according to certain criteria up to a computable point, then it will continue to oscillate and, hence, will not converge. The key requirement in their argument is that the weights for the n^{th} term be sharply concentrated around a single previous element in the sequence.

In [6] we consider a sequence, p_n, defined by

$$p_0 = 0; \quad p_1 = 1; \quad p_n = \frac{1}{2} \cdot p_{\lfloor \frac{n}{3} \rfloor} + \frac{1}{2} \cdot p_{\lfloor \frac{n}{2} \rfloor}, \quad n \geq 2.$$

This is a simple example of a sequence in which the n^{th} term is a weighted average of the preceding terms and the weights for p_n are heavily concentrated at two previous elements in the sequence. Although the double-biased sequence which we consider appears to be oscillating at the beginning, we show that it does, in fact, slowly converge. Specifically, we prove the following.

Theorem 3

$$\lim_{n\to\infty} p_n = \frac{2}{1+\log_2 3}.$$

In fact we prove a slightly more general result that allows the two weights to differ from 1/2. For the postdoctoral fellowship we propose three problems arising from this result.

The general double-biased case There are two generalizations in the double-biased case. First, we would like to characterize the behavior of the sequence in the double-biased case in which the weights are at locations other than 1/3 and 1/2; that is, $p_n = q \cdot p_{\lfloor \alpha n \rfloor} + (1-q) \cdot p_{\lfloor \beta n \rfloor}, \quad 0 < \alpha, \beta < 1$. It is not at all clear whether the sequence will converge even for other very simple cases. However, we hope to be able to use the methods in our current proof for $\alpha, \beta \in \mathbb{Q}$. Secondly, we propose to study the same problem, but allowing α and β to be irrational. A completely different method than the one described in [6] is required in this case.

Triple-biased case The final problem is to explore the nature of triple-biased (or higher) sequences.

2 Justification for Research Abroad

Simon Fraser University has excellent credentials to serve as a host for this postdoctoral experience.

2.1 Collaborators and their work

At SFU, I will have the opportunity to work with internationally recognized mathematicians as well as young faculty with outstanding potential. The researchers I plan to collaborate with fall into two general research groups: the computer algebra group and the discrete math group.

The director of the computer algebra group is Michael Monagan. Professor Monagan has participated in the development and design of the Maple computer algebra system throughout the last twenty years. Additionally, he shares with me research interests in algebraic geometry, Gröbner bases and algorithms. As mentioned earlier, Monagan and de Kleine [9] have recently developed a modular algorithm for computing Gröbner bases. Hence, Monagan is an ideal collaborator for the first two proposed problems from the previous section. Peter Borwein is a prolific member of the computer algebra group. His current research interest include polynomials and computation. I expect to collaborate with him on, among other projects, the third proposed problem from the previous section. Nils Bruin is a new faculty member at SFU working in the areas of computational algebraic number theory and geometry. He also has recently spent time with the research group in Sydney, Australia, that maintains the computer algebra system Magma.

In the discrete math group, I hope to work closely with Professors Petr Lisonek and Luis Goddyn. Lisonek is interested in various discrete problems in computation, combinatorics and error-correcting codes. His interests in coding theory and computer algebra will be of use in collaborating on the proposed coding applications above. He also is affiliated with the acclaimed symbolic computation research group in Linz, Austria. Goddyn's research interests are in combinatorial optimization and graph theory.

All of these individuals have overlapping research interests with me. In addition, the research groups they are members of hold regular seminars promoting interaction with one another and providing seminars promoting interaction with one another and providing opportunities for interaction with researchers from other universities. These research groups also have other postdoctoral fellows and graduate students involved.

Besides the research groups above, I will be involved with the Center for Experimental and Constructive Mathematics (CECM) under the directorship of Professor Monagan and with the MITACS (Mathematics of Information Technology and Complex Systems) symbolic computation group led by Professor P. Borwein. It is also worth mentioning that the Vancouver area is home to two other major research universities and numerous smaller colleges. There is significant collaboration among researchers at these universities, particularly between SFU and the nearby University of British Columbia.

2.2 Facilities available at SFU

SFU has outstanding computing facilities. In addition to "normal" computer resources, SFU has a state of the art high performance computing laboratory called HPC@SFU. This facility is home to powerful computers, including an 8cpu SGI Origin, a 192cpu Beowulf cluster, a 32cpu Alpha-clump and, recently, the third Canadian Interconnected Scientific Supercomputer (CISS-3). It also is part of the 30 million dollar BC and Alberta WestGrid initiative offering distributed and diverse high-end computing resources. HPC@SFU and CECM jointly host CoLab, an endeavor dedicated to encouraging and providing the means for collaboration in mathematical and computational research.

3 Long-term Career Goals

Briefly, my career goal is to be a research mathematician. I enjoy the challenge and excitement of working on and solving problems, especially those with a discrete or algebraic flavor.

At this point there are two possible scenarios in which I envisage this goal being fulfilled. The first is in a math or applied math department at a research university. In this way I would be in position to stay actively involved in the research community as well as be in a place to train and influence others. The flexibility of the university schedule also allows time for interaction with researchers in other areas of the world via extended semester breaks and sabbaticals. If my career is to stay in academia, I could imagine myself being involved in an administrative role later on.

A second work environment that is a possibility is with the United States government–most likely with the National Security Agency or the Department of Defense. Obviously, these positions are contingent on close review by the employer, but I am interested in some of the areas that I know they are interested in. Additionally, I would enjoy benefitting my country in such a position.

This postdoctoral position would aid my career goals on several fronts. First, many math departments of leading research universities are tending toward the policy that young Ph.D.'s with no postdoctoral experience probably need not apply. A postdoc would also give additional time to learn, to gain experience, to broaden my areas of research and to make new professional contacts. This would be especially helpful if I take a government position early in my career in which case collaboration opportunities with outside mathematicians would be limited.

The particular benefits of research at my chosen international host of

Simon Fraser University were outlined in the previous section. We again point out, though, that SFU is home to a number of young faculty, postdocs and graduate students in the research areas which interest me. The contacts made during this postdoctoral fellowship hopefully will lead to many fruitful collaborations for years to come.

Finally, the travel money that is a unique feature of this program will be a great help to me as I hope to keep in contact with my collaborators and research groups in the United States. Also, I expect to travel within the proposed host country of Canada as the membership of several research groups that I will be involved with at SFU, such as MITACS and PIMS, bridge a number of different institutions. Further, I hope to have new opportunities for collaborations by visiting researchers in the computer algebra communities of Europe and, possibly, of Australia. Some of the faculty at SFU have close ties to institutions (RISC-Linz, ETH-Zurich, Magma group at University of Sydney) in these locales.

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[27] Q. N. Tran, Implicitization of Rational Patches using Gröbner Walk, *preprint*

Jeff Farr, Mathematical Sciences, Clemson University

Education.
Ph.D., December 2003, Mathematical Sciences, Clemson University
M.S., December 1999, Mathematical Sciences, Clemson University
B.S., May 1998, Mathematics, Bob Jones University

Employment.
Jan 2004 – Dec 2004, Postdoctoral Fellow, Mathematics, Simon Fraser University.
Aug 2000 – Dec 2003, Graduate Research Assistant, Mathematical Sciences, Clemson University.
Jan 1998 – Dec 2002, Graduate Teaching Assistant, Mathematical Sciences, Clemson University.

Honors and Awards.
• Award for Significant Contribution to the Graduate Program, Clemson University Mathematical Sciences, 2002.
• R.C. Edwards Graduate School Fellowship, Aug 1999 – May 2000, Clemson University.
• Clayton V. Aucoin Outstanding Masters Student Award, 1999

Professional Activities.
Journal referee;
Local organizer, East Coast Computer Algebra Day, Clemson University, April 2003;
Member, American Mathematical Society, 2000–present;
Member, SIAM, 2002-present;
Contributed talk at International Conference for Applications of Computer Algebra, Raleigh, July 2003;
Contributed talk at Special Session in Computational Algebraic and Analytic Geometry for Low-dimensional Varieties, AMS/MAA Joint Mathematics Meetings, Baltimore, January 2003;
Contributed talk at Southeast Regional Meeting on Numbers (SERMON), Clemson, South Carolina, March 2002;
Contributed talk at Thirty-third Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Boca Raton, March, 2002;
Workshop participant, Workshop on algorithmic number theory, MSRI, August 2000.

Publications and Preprints.

1. Neil Calkin and Jeff Farr, "Slow Convergence of a Double-Biased Sequence," *Congressus Numerantium* **159** (2002), 159–165.

2. Jeff Farr, S.T. Hedetniemi, R. Laskar, *et al.*, "Gallai Theorems Involving Domination Parameters," *Congressus Numerantium* **157** 2002, 149-157.

3. Jeff Farr, "Renu Laskar: Changing Obstacles into Opportunities," AWM Biographical Essays, published online at
http://www.awm-math.org/biographies/contest/JeffreyFarr2002.html.

4. Jeff Farr and Shuhong Gao, "Computing Gröbner bases for vanishing ideals of finite sets of points," *preprint*, available online at
http://www.math.clemson.edu/ jeffref/research.html.

5. Jeff Farr and Shuhong Gao, "Gröbner bases and generalized Padé approximation," *preprint*, available online at
http://www.math.clemson.edu/ jeffref/research.html.

6. Jeff Farr, Shuhong Gao and Dan Noneaker, "Construction and decoding performance of random linear codes," *in preparation*.

PhD Thesis advisor: Shuhong Gao (Clemson University).

Postdoctoral Advisors:
Peter Borwein, Michael Monagan, Petr Lisonek (Simon Fraser University)

Other references:
Joel Brawley (Clemson University),
Neil Calkin (Clemson University),
Jennifer Key (Clemson University).

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Clemson University**				**FOR NSF USE ONLY** PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Jeffrey B Farr**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jeffrey B Farr - none	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 9,000 3. SUBSISTENCE 45,000 4. OTHER 7,800					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				61,800	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				61,800	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				61,800	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 61,800	$
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Jeffrey B Farr**	**FOR NSF USE ONLY** INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Dianne myers**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION: Clemson University	FOR NSF USE ONLY	
	PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Jeffrey B Farr	AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Jeffrey B Farr - none	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 9,000					
3. SUBSISTENCE 45,000					
4. OTHER 2,500					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				56,500	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				56,500	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				56,500	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 56,500	$

M. COST SHARING PROPOSED LEVEL $ Not Shown | AGREED LEVEL IF DIFFERENT $

PI/PD NAME: Jeffrey B Farr	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: Dianne myers	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET — Cumulative

ORGANIZATION: **Clemson University**				FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months): Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Jeffrey B Farr**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months: CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Jeffrey B Farr - none	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				0		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $ 0						
2. TRAVEL 18,000						
3. SUBSISTENCE 90,000						
4. OTHER 10,300						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				118,300		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				0		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				0		
H. TOTAL DIRECT COSTS (A THROUGH G)				118,300		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				0		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				118,300		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 118,300	$	
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME: **Jeffrey B Farr**				FOR NSF USE ONLY: INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: **Dianne myers**				Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification

October 8, 2003

1 Financial resources anticipated

No resources are anticipated for the time period requested. I have received promise of $ 35,000 (Canadian) from Simon Fraser University for the 2004 calendar year; however, I do not have any support for 2005 or 2006, the years for which I am asking support.

2 Travel justification

I anticipate travelling by air twice per year within the host country of Canada. This is reasonable since the research groups I will be working with span several institutions across Canada. Anticipated cost is $ 500 per ticket.

I also anticipate return travel twice per year to the U.S. to maintain current collaborative efforts at home. Estimated cost is $ 500 per ticket.

Further, I hope to travel once per year to Europe or Australia to develop collaborations there. Estimated cost is $ 1500 per ticket.

3 Estimated costs

Travel:

Airfare: $ 3500 per year;

Meals/Lodging: 5 weeks at $1000 per week = $ 5000 per year;

Roundtrip from home: $ 500 + $ 500 (1 dependent) = $ 1000, first year only;

Total Travel: $ 9000 per year.

Subsistence:

Living Allowance: 12 months at $3500 per month = $ 42000 per year;

Dependent Allowance: 12 months at $150 per month = $ 1800 per year;

Health Insurance: 12 months at $ 50 + $ 50 per month (1 dependent) = $ 1200 per year;

Total Subsistence: $ 45000 per year.

Other:

Relocation: $ 2500 per year;

Excess Baggage: $ 300, first year only;

Computer Workstation: $ 5000, first year only;

Total Other: $ 7800 first year, $ 2500 second year.

Total Estimated Costs: $61,800 first year, $56,500 second year.

SIMON FRASER UNIVERSITY

DEPARTMENT OF MATHEMATICS

8888 UNIVERSITY DRIVE
BURNABY, BRITISH COLUMBIA
CANADA VSA 156
Telephone: 604-291-3331
Fax: 604-291-4947

15 May 2003

PERSONAL AND CONFIDENTIAL

Mr. Jeffrey Farr
Department of Mathematical Sciences
O-7 Martin Hall
Clemson University
Clemson, SC
29634-0975
U.S.A.

Dear Mr. Farr:

It is a pleasure to offer you a Postdoctoral Fellowship for the period from 1 January 2004 to 31 December 2004 at a stipend of $ 35,000 (Canadian) per annum. This is inclusive of vacation pay. In addition, there will be statutory benefits (Canada Pension, Employment Insurance, Workers' Compensation, and Employment Standards Act benefits such as statutory holidays); additional benefits as detailed below will also be provided. Additional employment may be available after the above date, but will be subject to the satisfactory performance of all requirements and the availability of grant or contract funds. There will be no reimbursement of your moving expenses.

Additionally, you will be offered the sessional appointment of teaching 1undergraduate course in 1 semester during your period of employment. The remuneration for teaching 1 course is $ 5,100.

The offer of Postdoctoral Fellowship and the offer of sessional teaching appointment are conditional upon obtaining approval by Canada Employment and upon your successful completion of the Ph.D. program at Clemson University.

As a Postdoctoral Fellow you will have access to the University Library, computing services, recreational facilities and all facilities of the Centre for Experimental and Constructive Mathematics in the Department of Mathematics. You and your activities will be covered by all relevant University Policies and Procedures. I enclose a copy of

SFU Policy R50.03 which relates directly to your appointment. For general information on Simon Fraser University, our policies and our research activities and facilities, please visit our website www.sfu.ca.

This is primarily a research position. You will be expected to participate in the activities of the combinatorics group (Lisonek, Goddyn and Stacho) and the computer algebra group (Borwein, Monagan) and generally be involved in the research life of the department.

This employment will be administered by Simon Fraser University, although technically the contract of employment exists between you and me, as a recipient of research grant and/or contract funds; this employment relationship does not extend to or affect Simon Fraser University.

Additional Benefits:	Employee's Share	Grant Share
Basic Health & Hospital Insurance	50%	50%
Extended Health Coverage	50%	50%

Unless otherwise specifically stated in writing, the conditions of employment will be in accordance with the requirements set out in the B.C. Employment Standards Act and Regulations. You may wish to consult the terms of the Act and Regulations, including the complaint process outlined in Part 10 of the Act. Information regarding the Act can be found at: http://www.labour.gov.bc.ca/esb/chapter/print2.htm. The complaint process is explained there in Chapter 15. Termination of this contract of employment may be initiated by either party giving two (2) weeks notice, except in the case of termination for cause.

I hope you will accept these terms of employment; please sign and return the enclosed a copy of this letter, retaining the original for your records.

Yours truly,

Dr. Peter Borwein

I agree to the conditions of employment as set out above.

Jeffrey Farr

Date

Curriculum Vitae

Michael Burnett Monagan

Department of Mathematics and Statistics,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Canada
E-mail monagan@cecm.sfu.ca
Tel: (604) 291-4279 (Office)
Tel: (604) 291-5615 (Lab).

Education

1989 Ph.D. (in computer science), University of Waterloo, Canada
1983 M.Math. (in computer science), University of Waterloo, Canada
1981 B.Sc. Hons I (in computer science), Massey University, New Zealand

Employment History

9/99–present. Associate Professor, Department of Mathematics and Statistics, Simon Fraser University, Canada.
9/96–present. Associate Member, Department of Computer Science, Simon Fraser University, Canada.
11/95–9/99. Assistant Professor, Department of Mathematics and Statistics, Simon Fraser University, Canada.
9/90–9/95, Oberassistent, Institute for Scientific Computing, ETH Zurich, Switzerland.
9/89–8/90, Postdoktorand, Department of Computer Science, ETH Zurich, Switzerland.
9/88–8/89, Ph.D. student (computer science), University of Waterloo, Canada.
4/87–9/88, Visiting Scientist (Scratchpad group), IBM Research, Yorktown Heights, U.S.A.
1/83–4/87, Ph.D. student (computer science), University of Waterloo, Canada.
9/81–12/82, Master's student (computer science), University of Waterloo, Canada.
1/80–8/81, Junior lecturer (computer science), Massey University, Palmerston North, New Zealand.

3/78–12/80, Undergraduate student (computer science), Massey University, Palmerston North, New Zealand.

Research Grants and Awards

2003 MITACS NCE research project "Symbolic Analysis" (2003-2005). For \$200,000 (MITACS) and \$100,000 (Waterloo Maple) per year for three years. With P. Borwein (principal investigator) and others.

2000 NSERC Research Grant (2000-2004): "System Design and Algorithms for Simplification". For \$23,000 (NSERC) per year for four years.

1999 MITACS NCE research project "Symbolic Analysis" (1999-2003). For \$135,000 (MITACS) and \$75,000 (Waterloo Maple) per year for four years. With P. Borwein (principal investigator) and others.

1998 PIms Industrial Postdoctoral Fellowship for Dr. Petr Lisonek (1998): "Simplification in Computer Algebra Systems". For \$10,000 (PIMS) and \$20,000 (Waterloo Maple).

1998 NSERC Equipment Grant: "Basic Computing Facilities for a Symbolic Computing Group". For \$28,000 (NSERC), \$10,000 (Waterloo Maple) and \$8,000 (SFU).

1997 ASI New Faculty Fellowship (1997) for \$10,000 (ASI). To make contact with local industry to determine their need for symbolic computation in particular, scientific computation in general.

1996 NSERC Equipment Grant (1996) for \$45,000 (NSERC). With P. Borwein (principal investigator) and J. Borwein.

1996 NSERC Operating Grant (1996-2000): "An Extensible Simplifier for Algebraic Formulae". \$19,000 (NSERC) per year for four years.

1995 NSERC New Faculty Support Award (1995-1998): "Automatic Differentiation, Polynomial Factorization, Greatest Common Divisors and Simplification". \$45,000 (NSERC) plus \$15,000 (Waterloo Maple) per year for three years.

1995 Telelearning NCE (1995-2003): \$79,650 per year for seven years. Co-investigator with J. Borwein (principal investigator) and others.

Background and Current Interests

My university background is primarily in computer science. My field of expertise is *computer algebra* or *symbolic computation*. My other background and interests include programming languages and compilers, scientific computation and automatic differentiation, data structures, analysis of algorithms and theory of computation, cryptography, commutative algebra, and Groebner bases.

I am presently a member of the Maple group, actively working in the research and development of the Maple system. My involvement with the Maple group at Waterloo, a university research group working in computer algebra, began in 1982 when I took a course in symbolic computation for my Masters degree. There I completed my Ph.D. under Professor Gaston Gonnet in 1989 in the area of mappings from rings, e.g. algebraic number fields, into finite rings and fields, and their application.

I have worked on three of the large projects in the field of computer algebra, namely, the Maple project at Waterloo, the AXIOM (formerly Scratchpad II) project with Dick Jenks and Stephen Watt at IBM Research, Yorktown Heights, and the Magma project with John Cannon and Allan Steel at the University of Sydney, Australia. The list of publications, in particular the MapleTech publications will give you an idea of other topics that I have worked on. Not included in the publications is that I have studied and implemented much of the basic polynomial arithmetic in Maple, i.e. polynomial division, greatest common divisors, resultants, and factorization which lie at the heart of the system. During my visit to IBM Research in 1987 I worked on the design and implementation of the hierarchy of data structures in Scratchpad, and the back-end of the new compiler with Dr. Stephen Watt. During my visit to Sydney in 2003 I worked on an implementation of a modular GCD algorithm in Magma for multivariate polynomials over number fields.

My knowledge of Maple has resulted in collaborations in application areas such as molecular physics, molecular spectroscopy, number theory, geophysics, computer vision, etc., which have often resulted in joint publications. A computer algebra system bridges mathematics and computer science with an application field. For my part, these collaborations have typically involved developing and implementing more efficient algorithms for solving, sometimes difficult, computational mathematical problems.

I am presently employed in the department of mathematics at Simon

Fraser University. There I am director of the Centre for Experimental and Constructive Mathematics (CECM), director of the Computational Algebra Group (CAG) within the CECM, and co-leading our MITACS symbolic analysis project with Peter Borwein (PI). The CAG has met weekly since May 1997. The current active faculty members are myself, Dr. Peter Borwein, Dr. Petr Lisonek, and Dr. John Ogilive. Over the last five years we have had six PDFs, Dr. Petr Lisonek, Dr. Janez Ales, and Dr. Edgardo Cheb-Terrab, Dr. Mathew Klassen, Dr. Agnes Szanto, and Dr. Andrew Solomon, Some of our research interests include (i) automatic differentiation and code generation, (ii) simplification of formulae, (iii) modular algorithms for polynomial computation, (iv) Gröebner bases and ideal theoretic algorithms, (v) high precision numerical computations, (vi) normal forms for systems of ODEs, PDEs, DAEs, (vii) algorithms for ODEs such as the Abel ODE.

My present research work includes both mathematical algorithms and system design. In the algorithms area, I am working on multivariate polynomial factorization and greatest common divisors, computing with algebraic numbers, and the simplification problem and I'm now looking at algebraic number fields, algebraic function fields, and rings which are not UFSs such as trigonometric polynomials.

Teaching Experience

Nominations and Awards

I was nominated in 2001 for a faculty of Science teaching award, but was not given this award.
I was nominated in 2002 for a faculty of Science teaching award and received it.
I was nominated in 2002 for a univerity teaching award at SFU but was not tiven this award.

Courses Given

1996-1, 1996-2: *Calculus II.* A first year course on integral calculus for the biological sciences given at SFU.

1997-2, 1998-1: *Discrete Mathematics II.* Text: "Discrete and Combinatorial Mathematics" by R. Grimaldi.
A second course in discrete mathematics given at SFU.

1999-1, 2000-1, 2002-1: *Modelling and Computation.*
Text: "Understanding Nonlinear Dynamics" by Kaplan and Glass.
This course had two goals, firstly, to train students to be proficient in the use of Maple for use in latter courses, and secondly, to introduce students to a number of continuous and discrete models and to get them to analyze the model. The course differs from most textbooks on modelling in that we assume first year calculus and competency in programming - so we demand more.

2001-2: *Introduction to Linear Algebra.*
Text: "Linear Algebra" by Faleigh and Beuregard.
A first course (second year students) on linear algebra with a focus on theory.

1981-2: *Advanced Computer Science*
Text: "Algorithms + Data Structures = Programs" by N. Wirth.
This course covered data structures (linked lists, trees, graphs), and an introduction to compilers and operating systems given to senior undergraduate students at Massey University.

1998-3, 2002-3: *Introduction to Applied Algebraic Systems.*
Text: "Introduction to Applied Algebraic Systems" by N. Reilly. A first course on Groups, Rings, & Fields with a focus on finite fields given to third year undergraduate students at SFU.

1992-1, 1993-1: *Introduction to Computer Algebra.*
Text: "Algorithms for Computer Algebra" by Geddes, Czapor and Labahn. This course is a first course in computer algebra given to senior undergraduate students at ETH Zurich.

1995-2: *Computer Algebra II.*
Text: "Algorithms for Computer Algebra" by Geddes, Czapor and Labahn. A course on algorithms and data structures for multivariate polynomials e.g. polynomial GCDs, and Grobner bases given to senior undergraduate students at ETH Zurich.

1996-3, 1998-2, 1999-1, 2000-1: *Introduction to Computer Algebra.*
Text: "Algorithms for Computer Algebra" by Geddes, Czapor and Labahn. A first course on computer algebra given to senior undergraduate students in mathematics and computing, and also to mathematics, applied mathematics, and computing graduate students.

2003-3 *Computer Algebra*
Text: "Algorithms for Computer Algebra" by Geddes, Czapor and Labahn. A graduate course in computer algebra given to 2 computing and 3 math graduate students.

1999-2, 2001-2: *Introduction to Groebner Bases and Non-linear Algebra.*
Text: Ideals, Varieties and Algorithms: An Introduction to Computational Commutative Algebra and Algebraic Geometry by Cox, Little, and O'Shea.

2002-2: *Cryptography.*
(MATH 800/CMPT 881/MACM 498).
Text: "Theory and Practice" by Douglas Stinsen. Given to (20) senior undergrate students, 5 mathematics graduate students and 10 computing science graduate students.

1998-2, 1999-2, 2000-2, 2001-2, 2002-2: *Teaching & Doing Mathematics with Maple.*
A one week course (8:30am - 5pm), given to industry and to highschool/college/university mathematics instructors. See http://www.cecm.sfu/MapleBrochure02.pdf for a copy of the course brochure.

Student Supervision

Undergraduate Students

At ETH Zurich I supervised six student "Diplomarbeits" and two student "Semesterarbeits". A Diplomarbeit is roughly equivalent to an undergraduate thesis which must be completed in exactly 4 months of full-time work. A Semesterarbeit is a term project of 150 hours work, equivalent to a one semester course.

2003 Scott Cowan, NSERC Undergraduate Fello. Computational problems in cryptography and algebra.

2002 Aaron Bradford, NSERC Undergraduate Fellow. Algorithms for pattern matching and simplification.

2001 Roman Pearce, NSERC Undergraduate Fellow. Algorithms for computing Groebner bases, converting Groebner bases to different orderings.

2001 George Zhang, NSERC Undergraduate Fellow. Algorithms for operations on ideals including testing if an ideal is prime or maximal over a given field.

2000 Jamie Mulholland, NSERC Undergraduate Fellow, Algorithms for GCDs and Factoring Trigonometric Polynomials i.e. in the ring $\mathbf{Q}[\mathbf{s},\mathbf{c}]/<\mathbf{s^2}+\mathbf{c^2}-\mathbf{1}>$ based on the tan half angle map. Winner of the deans silver medal for 1999 for the best undergraduate student in science.

2000 Craig Pastro, NSERC Undergraduate Fellow, Implementation of modular GCD algorithm for multivariate polynomials of finite fields and number fields.

2000 Ricky Leung, MATH 497-3 Directed Studies, Computing Groebner Bases and Modular Methods.

1999 Michael Ludkovski, MATH 497-3 Directed Studies, Brown's dense modular GCD algorithm and Zippel's sparse modular GCD algorithm. Winner of the deans silver medal for 2000 for the best undergraduate student in science.

1999 Mark Siggers, MATH 493-4 Directed Studies, Linear univariate Hensel lifting, and a generic implementation over Euclidean rings.

1998 Colin Percival, Carreer Prep Project GCDs over algebraic number fields. Winner of a Putnam Award, 2000.

1995 Rene Rodoni, Diplomarbeit, "An Implementation of the FORWARD and REVERSE MODE in Maple."

1995 Roger Margot, Diplomarbeit, "Univariate polynomial GCD's over $Q(\alpha)$."

1993 Igor Berchtold, Diplomarbeit, "Sparse Matrix Determinants over Integral Domains."

1993 Laurent Bernardin, Diplomarbeit, "Factorization of multivariate polynomials over a finite field."

1992 Walter Neuenschwander, Diplomarbeit, "Algorithmische Differentiation."

1992 Stefan Schwendimann, Diplomarbeit (co-supervised with Dr. Tyko Strassen), "Ein Softwarepaket fuer die algebraische, projektive Geometrie."

Graduate Students

02- Aaron Bradford (Simon Fraser), a Master's student in mathematics. Computer algebra.

01- Roman Pearce (Simon Fraser), a Master's student in mathematics. Algebraic geometry and Gröbner bases.

97- Allan Wittkopf (Simon Fraser), a PhD student in applied mathematics Standard Forms for Systems of PDE and DAE (with Greg Reid).

99-01 Jennifer de Kleine (Simon Fraser). *A Modular Design and Implementation of Buchberger's Algorithm*, Master's thesis in computer science, November 2001.

01-02 Stephen Tse (Simon Fraser). *Algorithms and Bounds for Resultants*, Master's thesis in computing science, July 2002.

94-99 Laurent Bernardin (ETH Zurich). *Factorization of Multivariate Polynomials over Finite Fields*, PhD dissertation in computing science, September 1999. Co-supervised and co-examined with Gaston Gonnet.

Post Doctoral Fellows

At Simon Fraser I supervised

Dominique Villard 03/97 - 06/99 Dominique has implemented a package called ADrien for doing automatic differentiation in Maple with a link to MATLAB.

Petr Lisonek 05/97 - 08/00 Petr has looked at the implementation of a multivariate version of the Risch structure theorem.

Edgardo Cheb-Terrab 02/99 - present. in the area of differential equations and non-commutative algebras.

Janez Ales 01/00 - 08/01. Janez has implemented a sparse implementation of revised simplex for the simplex package in Maple and had looked at algorithms for univariate and bivariate polynomial factorization.

Professional Activities

2002- Director, Centre for Experimental and Constructive Mathematics. Within the department of mathematics and statistics at Simon Fraser. See http://cecm.sfu.ca .

1999: Local arrangements chair for ISSAC '99, Vancouver, July 1999. This is the main yearly event in my field.

1997- Director, Computational Algebra Group, SFU.
See http://cecm.sfu.ca/ CAG .

1996-2002: Associate Director of the Centre for Experimental and Constructive Mathematics, Simon Fraser University.

1998: Coeditor with Norbert Kajler of the Journal of Symbolic Computation special issue on Graphical User Interfaces and Protocols, JSC **25** (2) 1998.

1997: Coeditor with James Herod of *Maple in the Physical Sciences*, MapleTech Vol 4 No. 2, Birkhauser, Boston, 1997.

1997: Coeditor with Jon Borwein of *Maple in the Mathematical Sciences*, MapleTech Vol 4 No. 1, Birkhauser, Boston, 1997.

1996: Problems section co-editor with G.J. Fee of the SIGSAM Bulletin, ACM Press. This involves collecting interesting or challenging problems to be solved.

1994: Coeditor with Tony Scott of *Maple in Mathematics and the Sciences*, Special Issue, MapleTech, Birkhauser, Boston, 1994.

1994-1998: Functionality section editor of MapleTech. This involves reading and organizing the refereeing of papers submitted to this section and writing a column for this section.

1993-1997: Systems section editor for the Journal of Symbolic Computation. This involved organizing the refereeing of papers submitted to this section.

Member ACM, ACM SIGSAM, AMS, SIAM.

Programme committee member ISSAC '94, DISCO '93, ISSAC '92.

NSERC referee, 1999, 2000, 2001, 2002.

Refereed Journal Papers

Note: "MapleTech" was published by Birkhauser, Boston. I was a senior editor of MapleTech. MapleTech became a formally refereed publication with Volume 1 Number 1 in Spring 1994. All MapleTech publications listed here were independently refereed. All other MapleTech articles, such as the Tips for Maple Users and Programmers column that I wrote are included in the non-refereed publication section of this CV.

1999 M.B. Monagan, J.F. Ogilvie, The Diatomic Anharmonic Oscillator according to Matrix Mechanics. Mathematics and Computers in Simulation, **49** (3), pp. 221–234, Elsevier, 1999.

1999 M. B. Monagan, M. A. Slawinski, The Sensitivity of Traveltime Inversion for an Anisotropic Parameter in Seismology. MapleTech, **5** No. 2 & 3, pp. 107–116, Birkhauser, 1999.

1997 Robert M. Corless, David J. Jeffrey, Michael B. Monagan, and Pratibha, Two Perturbation Calculations in Fluid Mechanics using Large-expression Management, *J. of Symbolic Computation*, **23** No. 4, pp. 427–443, 1997.

1997 John F. Ogilvie and Michael B. Monagan. Symbolic Computation in Molecular Spectroscopy, *Maple in the Physical Sciences*, MapleTech **4** No. 2, pp 100–108, Birkhauser, 1997.

1997 T.C. Scott, I.P. Grant, M.B. Monagan, and V.R. Saunders, Generation of Optimized Vectorized Fortran Code for Molecular Integrals of Gaussian-Type Functions. *Maple in the Physical Sciences*, MapleTech **4** No. 2, pp. 15–24, Birkhauser, 1997.

1997 M. B. Monagan, Worksheets and Notebooks: Can We Teach Mathematical Algorithms with Them? JSC Special Issue on Symbolic Computation in Undergraduate Teaching. *J. of Symbolic Computation*, **23** No. 5, pp. 535–550, 1997.

1997 Carollyne Guidera and Michael Monagan, Introductory Differential Equations: New Tools Give New Understanding to Students. *Maple in the Mathematical Sciences*, MapleTech **4** No 1, pp. 59–67, Birkhauser, 1997.

1994 D. Würtz, M. Monagan, and R. Peikert, The History of Packing Circles in a Square. *Maple in Mathematics and the Sciences*, MapleTech, Special Issue, pp. 35–42, Birkhauser, 1994.

1993 M. B. Monagan, The Maple Computer Algebra System. *Comp. Sci. J. of Moldova*, **1** No. 2, pp. 49-63, Academy of Sciences of Moldova, 1993.

1992 M. B. Monagan, A Heuristic Irreducibility Test for Univariate Polynomials. *J. of Symbolic Comp.*, **13** No. 1, pp. 47-57, 1992.

1992 R. Peikert, D. Würtz, M. Monagan and C. de Groot Packing Circles in a Square: A Review and New Results. *System Modelling and Optimization*, Springer-Verlag LNCIS **180**, pp. 45–54, 1992.

1990 T.C. Scott, R.A. Moore, G.J. Fee, M.B. Monagan, G. Labahn and K.O. Geddes, Perturbative Solutions of Quantum Mechanical Problems by Symbolic Computation: A Review. *Int. J. of Modern Physics*, **1** No. 1, pp. 53–76, 1990.

1990 T.C. Scott, R.A. Moore, M.B. Monagan, G.J. Fee and E.R. Vrscay, Perturbative Solutions of Quantum Mechanical Problems by Symbolic Computation. *J. Comp. Physics*, **87**, No. 2, pp. 366–395, 1990.

1989 T.C. Scott, R.A. Moore and M.B. Monagan, Resolution of Many Particle Electrodynamics by Symbolic Computation. *Computer Physics Communications*, **52**, pp. 261–281, 1989.

1988 Andrew Granville and Michael Monagan, The First Case of Fermat's Last Theorem is True for all Prime Exponents up to 714,591,416,091,389. *Transactions of the AMS*, **306** No. 1, pp 329–359, 1988.

1988 T.C. Scott, R.A. Moore and M.B. Monagan, A Model for a Relativistic, Many-Particle Lagrangian with Electromagnetic Interactions, Canadian J. of Physics, **66** No. 3, pp 206–211, 1988.

1987 T.C. Scott, R.A. Moore and M.B. Monagan Relativistic, Many-Particle Lagrangean for Electromagnetic Interactions. *Physical Review Letters*, **59** No. 5, pp 525–527, 1987.

1986 B.W. Char, G.J. Fee, K.O. Geddes, G.H. Gonnet and M.B. Monagan, A Tutorial Introduction to Maple. *J. Symbolic Comp.*, **2** No. 2, pp 179–200, 1986.

Refereed Conference Papers

2002 M. van Hoeij, M. B. Monagan, A Modular GCD Algorithm over Number Fields Presented with Multiple Field Extensions. Submitted to ISSAC '02, January 2002. *Proceedings of ISSAC '2002*, ACM Press, pp. 109–116, 2002.

2002 J. de Kleine, M. B. Monagan, A Modular Design and Implementation of Buchberger's Algorithm. Submitted to the Rhine Workshop on Computer Algebra - RWCA '02, December 2001. Accepted for publication in January 2002. *Proceedings of RWCA '02*, 2002.

2001 J. Mulholland, M.B. Monagan, Algorithms for Trigonometric Polynomials. *Proceedings of ISSAC '2001*, ACM Press, pp. 245–252, 2001.

2000 M.B. Monagan, A.D. Wittkopf, On the Design and Implementation of Brown's Algorithm over the Integers and Number Fields. *Proceedings of ISSAC '2000*, ACM Press, pp. 225–233, 2000.

1999 E. Kaltofen, M.B. Monagan, On the Genericity of the Modular Polynomial GCD Algorithm. *Proceedings of ISSAC '99*, ACM Press, pp. 59–66, 1999.

1999 D. Villard, M.B. Monagan, ADrien: An Implementation of Automatic Differentiation in Maple. *Proceedings of ISSAC '99*, ACM Press, pp. 221–228, 1999.

1998 M.B. Monagan, M.A. Slawinski, On the Sensitivity of Thomsen's γ Parameter to Traveltime Errors. *Proceedings of SEG '98*, 1998. Note: the conference proceedings were published on CD ROM and also online at: `http://seg.org/seg98/techprog/tecprogm.html#st2`

1998 M.B. Monagan, R.D. Margot, On Computing Univariate GCDs over Number Fields. *Proceedings of SODA '98*, SIAM, pp. 42–49, 1998.

1997 M.B. Monagan, G.M. Monagan, A Toolbox for Program Manipulation and Efficient Code Generation with an Application to a Problem in Computer Vision. *Proceedings of ISSAC '97*, ACM Press, pp. 257–266, 1997.

1997 Laurent Bernardin, Michael Monagan. Efficient Multivariate Factorization Over Finite Fields. *Proceedings of AAECC '97*, Springer-Verlag LNCS **1255**, pp 15–28, 1997.

1997 T.C. Scott, I.P. Grant, M.B. Monagan, and V.R. Saunders, Numerical Computation of Molecular Integrals Via Optimized (Vectorized) FORTRAN Code. *Proceedings of the fifth International Workshop on New Computing Techniques in Physics Research (software engineering, neural nets, genetic algorithms, expert systems, symbolic algebra, automatic calculations), Nuc. Instruments & Methods Phys. Research.*, Elsevier, pp 117–120, 1997.

1996 M.B. Monagan, R.R. Rodini, An Implementation of the Forward and Reverse Modes of Automatic Differentiation in Maple. *Computational Differentiation: Techniques, Applications, and Tools*, SIAM, pp. 353–362, 1996.

1994 M. B. Monagan and G. H. Gonnet, Signature Functions for Algebraic Numbers. *Proceedings of ISSAC '94*, ACM Press, pp. 291-296, 1994.

1994 M. B. Monagan, Worksheets: Can we Teach Mathematical Algorithms with Them? *Proceedings of the 1994 Maple Summer Workshop*, Birkhauser, pp. 187–196, 1994.

1993 M. B. Monagan, Gauss: a Parameterized Domain of Computation System with Support for Signature Functions. *Proceedings of DISCO '93*, Springer-Verlag LNCS, **722**, pp. 81–94, 1993.

1993 M. B. Monagan and W. M. Neuenschwander, GRADIENT: Algorithmic Differentiation in Maple. *Proceedings of ISSAC '93* pp. 68–76, ACM Press, 1993.

1992 M. B. Monagan, In-place arithmetic for polynomials over $\mathbf{Z}_n$. *Proceedings of DISCO '92*, Springer-Verlag LNCS, **721**, pp. 22–34, 1993.

1992 T.C. Scott, M.B. Monagan, G.J. Fee and R. Corless, Some Applications of Maple Symbolic Computation to Mathematical, Scientific and Engineering Problems. *Artificial Intelligence, Expert Systems and Symbolic Computing*, Elsevier Science Publishers B.V. IMACS, 1992.

1990 T.C Scott, R.A. Moore, M.B. Monagan and G.J. Fee, Applications of Symbolic Computation to Relativistic Quantum Mechanics. *Proceedings of AI-HENP '90*, edited by D. Perret-Gallix and W. Wojcik, pp. 611–618, 1990.

SEG = Society for Exploration in Geophysics
SODA = Symposium on Discrete Algorithms
ISSAC = International Symposium on Symbolic and Algebraic Computation
AAECC = Applied Algebra and Error Correcting Codes
DISCO = Design and Implementation of Symbolic Computation Systems
AIHENP = Artificial Intelligence in High Energy and Nuclear Physics
LNCS = Lecture Notes in Computer Science
LNCIS = Lecture Notes in Control and Information Sciences
MSWS = Maple Summer Workshop

Invited Talks and Refereed Conference Talks

2003 Six Problems in Computational Algebra. Presented at the School of Computer Systems, University of Techology of Sydney, June 18th, 2003.

2003 Magma and the problem of computing GCDs over Number Fields. Presented at the Magma Computational Algebra Seminar, University of Sydney, March 20, 2003.

2002 2D and 3D Graphical Routines for Teaching Linear Algebra Presented at MSW '2002, Waterloo, Ontario, July 2002.

2002 A Modular GCD Algorithm over Number Fields Presented with Multiple Field Extensions. Presented at ISSAC '2002, Lille, France, July 2002. Presented at CECM '2002, Vancouver, BC, July 2002.

2000 Some Problems in General Purpose Computer Algebra Systems Design. Presented at ECCAD '2000, London, Ontario, May 2000.

1999 ADrien: An Implementation of Automatic Differentiation in Maple. Presented at ISSAC '99, Vancouver, July 1999.

1998 Generic *and* Efficient Algorithms. Presented at the Parallel Symbolic Computation Workshop, MSRI, Berkely, October 1998.

1998 On the Sensitivity of Thomsen's γ Parameter to Traveltime Errors. Presented at the Anisotropy: Moveout Analysis session at SEG '98, New Orleans, September 1998.

1998 On the Sensitivity of Thomsen's γ Parameter to Traveltime Errors. Presented at the Anisotropy Workshop at GEO-TRIAD '98, Calgary, June 1998.

1998 On Computing Univariate GCDs over Number Fields. Presented at SODA '98, San Francisco, January 1998.

1997 A Toolbox for Program Manipulation and Efficient Code Generation with an Application to a Problem in Computer Vision, Presented at ISSAC '97, Maui, July 1997.

1997 The Diatomic Anharmonic Oscillator According to Matrix Mechanics. Presented at IMACS ACA '97, Maui, July 1997.

1997 Codegen: A Toolbox for Manipulating Maple Programs, Presented at the West Coast Optimization meeting, Vancouver, April 1997.

1996 An Implementation of the Forward and Reverse Modes of Automatic Differentiation in Maple. Presented at the Second International Workshop on Computational Differentiation, Sante Fe, New Mexico, February 1996.

1994 Signature Functions for Algebraic Numbers. Presented at ISSAC '94, Oxford, England, July 1994.

1994 Worksheets: Can we Teach Mathematical Algorithms with Them? Presented at the MSWS '94, Troy, New York, August 1994.

1993 Gauss: a Parameterized Domain of Computation System with Support for Signature Functions. Presented at DISCO '93, Gmunden, Austria, September 1993.

1993 GRADIENT: Algorithmic Differentiation in Maple. Presented at ISSAC '93, Kiev, Ukraine, July 1993.

1992 In-place arithmetic for polynomials over $\mathbf{Z}_n$. Presented at DISCO '92, Bath, England, April 1992.

Books, Theses

2002 *Maple 8 Introductory Programming Guide* M.B. Monagan, K.O.Geddes, K.M. Heal, G.Labahn, S.M.Vorkoetter, J. McCarron, P. DeMarco. Waterloo Maple, 2002. ISBN: 1-894511-27-1.

2002 *Maple 8 Advanced Programming Guide* M.B. Monagan, K.O.Geddes, K.M. Heal, G.Labahn, S.M.Vorkoetter, J. McCarron, P. DeMarco. Waterloo Maple, 2002. ISBN: 1-894511-28-X.

1996 *Maple V Programming Guide* M.B. Monagan, K.O.Geddes, G.Labahn, S.M.Vorkoetter, Springer Verlag, 1996. ISBN: 0-387-94576-8

1992 *First Leaves: Tutorial Introduction to Maple V* B.W. Char, K.O. Geddes, G.H. Gonnet, B.L. Leong, M.B. Monagan and S.M. Watt, Springer Verlag, 1992.

1991 *Maple V Language Reference Manual* B.W. Char, K.O. Geddes, G.H. Gonnet, B.L. Leong, M.B. Monagan and S.M. Watt, Springer Verlag, 1991.

1989 M.B. Monagan, *Signatures + Abstract Types = Computer Algebra - Intermediate Expression Swell*. Ph.D. Thesis, University of Waterloo, 1989.

1989 *First Leaves: A Tutorial Introduction to Maple*, 3rd edition, 1989, B.W. Char, K.O. Geddes, G.H. Gonnet, M.B. Monagan, S.M. Watt. Watcom Publications Limited, Waterloo, Ontario, Canada.

1988 *Maple Reference Manual*, 5th edition, 1988, B.W. Char, K.O. Geddes, G.H. Gonnet, M.B. Monagan and S.M. Watt. Watcom Publications Limited, Waterloo, Ontario, Canada.

Research Reports, Posters and Other Publications.

Publications which were formally reviewed are designated with an *R*.

2003R R. Pearce, M. Monagan, The PolynomialIdeals Maple Package. Accepted for publication and presentation at the Maple Summer Workshop, July 2003.

2002R G. J. Fee, M. B. Monagan, Cryptography using Chebyshev Polynomials. Accepted for publication and presentation at the Maple Summer Workshop, July 2003.

2002R M. B. Monagan, G. J. Fee, A Cryptographically Secure Random Number Generator for Maple. Accepted for the Maple Summer Workshop, July 2003.

2002R M. Monagan, 2D and 3D Graphical Routines for Teaching Linear Algebra, Proceedings of the 2002 Maple Summer Workshop, Waterloo Maple Inc., 2002.

2002R J. de Kleine, M. Monagan, A Modular Method For Computing Gröbner Bases. Proceedings of the 2002 Maple Summer Workshop, Waterloo Maple Inc., 2002. Presented at the MSWS '02 poster session, the ISSAC '02 poster session and the MITACS AGM '02 poster session.

2002R M. Monagan, S. Tse, A. Wittkopf. Modular Algorithms for Resultants. Proceedings of the 2002 Maple Summer Workshop, Waterloo Maple Inc., 2002. Presented at the MSWS '02 poster session, the MITACS AGM '02 poster session (second prize).

2000 M. Monagan and J. Mullholland. Algorithms for Trigonometric Polynomials. Research Report. MITACS Symbolic Analysis Project. November 2000.

2000 M. Monagan, J. Ales, J. de Kleine, C. Pastro, and A. Wittkop. Data Structures and Algorithms for Polynomials, Research Report. MITACS Symbolic Analysis Project. November 2000.

2000 M. Monagan, P. Lisonek, H. Bauck. Simplification of Algebraic Expressions. Research Report. MITACS Symbolic Analysis Project. November 2000.

1999 Frederic Gourdeau, Michael B. Monagan, Joel Hillel, Working group D: Mathematical Software for the Undergraduate Curriculum. *Proceedings of the 1998 Annual Meeting of the Canadian Mathematics Education Study Group*, Mount Saint Vincent University Press, pp 59–70, 1998.

1998 Dominique Villard, Michael Monagan, Automatic differentiation: an implementation in Maple. Poster Session, ISSAC '98, Rostock, Germany, 1998.

1998 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **5** No. 1, 1998.

1997 David Barr, Lou Hafer, David Kirkpatrick, Ramesh Krishnamurti, Philip Loewen, Michael Monagan, Marc Paulhaus, Mihaela Radulescu, Optimial Lumber Production from Softwood Sawlogs. Proceedings of the first PIms Industrial Problem Solving Workshop, PIms IPS 1, pp 43–59, 1997.

1997 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **4** No. 3, 1997.

1997 Jon Borwein and Michael Monagan, Differential Equations in Maple: A Short Tutorial. *Maple in the Mathematical Sciences*, MapleTech Vol 4 No 1, pp. 55–68, 1997.

1996 Paul Zimmermann, Laurent Bernardin, Michael Monagan. Polynomial Factorization Challenges. Poster Session, ISSAC '96, Zurich, July 1996.

1996 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **3** No. 3, 1996.

1996 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **3** No. 2, 1996.

1995 Michael Monagan and René Rodoni. Automatic Differentiation: An Implementation of the Forward and Reverse mode in Maple, Poster Session, ISSAC '95, Montreal, July 1995.

1995 Laurent Bernardin and Michael Monagan On an Implementation of Multivariate Factorization over Finite Fields. Poster Session, ISSAC '95, Montreal, July 1995.

1995 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **2** No. 2, 1995.

1995 M. B. Monagan, Tips for Maple Users and Programmers, *MapleTech* **2** No. 1, 1995.

1995 M. B. Monagan, New Mathematical Capabilities of Maple V Release 4, *MapleTech* **2** No. 2, 1995.

1994 Tony Scott and Michael Monagan (editors), *Maple in Mathematics and the Sciences*, Special Issue, MapleTech, Birkhauser, Boston, 1994.

1994R Michael Monagan and Dominik Gruntz, Introduction to Gauss, SIGSAM Bulletin, **28** No. 2, pp. 3–19, August 1994.

1994 New Features in Maple V Release 3, Symbolic Computation Group, M.B. Monagan editor, Internal report, Institute for Scientific Computing, ETH Zentrum, 1994.

1994R M. Monagan and I. Berchtold, A Comparison of Algorithms for Sparse Matrices and Linear Systems. Proceedings of the Rhine Workshop on Computer Algebra, Jacques Calmet ed., pp 205–206, 1994. Workshop held at the University of Karlsruhe, March 22-24, 1994.

1994R M. B. Monagan, Computing Partial Derivatives using Algorithmic Differentiation. Proceedings of the 1993 Workshop on Symbolic and Numeric Computing, Hesinki University of Technology. Rolf Nevanlinna Institute Research Reports B10, pp. 41-59, 1994. Workshop held Helsinki, Finland, May 1993.

1994 A. J. Granville, M. B. Monagan, The Status of Fermats Last Theorem mid 1994. *Maple in Mathematics and the Sciences*, Special Issue, MapleTech, 1994.

1994 T. Scott, G. Fee, R. Corless, M. Monagan, Applications of Maple to Mathematical, Scientific, and Engineering Problems. *Maple in Mathematics and the Sciences*, Special Issue, *MapleTech* 1994.

1994 M. B. Monagan, Tips for Maple Users, *MTN* **1** No. 2, 1994.

1994R Robert Corless and Michael Monagan, Simplification and the Assume Facility *MTN* **1** No. 1, pp 24–31, 1994.

1994 M. B. Monagan, Tips for Maple Users, *MTN* **1** No. 1, 1994.

1994 Tony Scott, Richard Pavelle, Darren Redfern and Michael Monagan, Maple in Education - Part II *MTN* **1** No. 1, 1994.

1993R M. B. Monagan, von zur Gathen's Factorization Challenge. SIGSAM Bulletin, **27** No. 2, pp 13-18, April 1993.

1993 Ross Taylor and Michael Monagan, Thermodynamics with Maple: I - Equations of State *MTN* No. 10, 1993.

1993 M. B. Monagan, Tips for Maple Users, *MTN* No. 10, 1993.

1993 M. B. Monagan, Using Computer Algebra to Help Understand Eigenvalues and Eigenvectors *MTN* No. 9, 1993.

1993 Michael Monagan and Dominik Gruntz, Introduction to Gauss *MTN* No. 9, 1993.

1992 M. B. Monagan, Exact Eigenvalue and Eigenvector Computation in Maple, *MTN* No. 8, 1992.

1992 M.B. Monagan and J.S. Devitt, The D operator and Algorithmic Differentiation *MTN* No. 7, 1992.

1992 New Features in Maple V Release 2, Symbolic Computation Group, M.B. Monagan editor, Internal report, Institute for Scientific Computing, ETH Zentrum, 1992.

1991 R. Peikert, D. Würtz, M. Monagan and C. de Groot, Packing Circles in a Square: A Review and New Results *MTN* No. 6, 1991.

1991 R. Peikert, D. Würtz, M. Monagan and C. de Groot Packing Circles in a Square: A Review and New Results. IPS Research Report No. 91-17, September 1991, ETH-Zentrum, CH-8092 Zurich, Switzerland.

1991 Tony Scott, Mike Monagan, Greg Fee and Rob Corless, Some Applications of Maple to Mathematical Scientific and Engineering Problems *MTN* No. 6, 1991.

1991 G.J. Fee and M.B. Monagan, User Defined Aliases and Factorization over Finite and Algebraic Number Fields *MTN* No. 5, 1991.

1990 New Features that have been Added to Maple V, Symbolic Computation Group, M.B. Monagan editor, Internal report, Institute for Scientific Computing, ETH Zentrum, 1990.

1989 M.B. Monagan, The collect function in Maple, *MTN* No. 4, 1989.

1989 M.B. Monagan, Fortran translation and optimization, *MTN* No. 4, 1989.

1988 M.B. Monagan, Automatic simplifications in Maple, *MTN* No. 3, 1988.

1988 M.B. Monagan, On manipulating polynomials in Maple, *MTN* No. 3, 1988.

1987 A.J. Granville and M.B. Monagan, The first case of Fermat's last theorem *MTN* No. 2, 1987.

1987 M.B. Monagan, A plotting facility for Maple, *MTN* No. 2, 1987.

1986 M.B. Monagan, G.H. Gonnet and B.W. Char, Measurements and comparisons of SMP. Research report CS-85-47, University of Waterloo 1985. Technical correspondence section, *CACM*, **29** (7), July 1986, pp. 680-682.

1986R G.H. Gonnet and M.B. Monagan, Solving Systems of Algebraic Equations or the Interface between Software and Mathematics. Presented at Computers and Mathematics, Stanford, July 1986. Although refereed, no conference proceedings were ever published. The "paper" was later published as a Research report CS-89-13, University of Waterloo 1989.

1984R B.W. Char, G.J. Fee, K.O. Geddes, G.H. Gonnet, M.B. Monagan and S.M. Watt, On the design and Performance of the Maple System. *Proceedings of the 1984 Macsyma Users Conference*, Schenectady, N.Y. 1984. Also published as Research report CS-84-13, University of Waterloo, 1984.

Explanation of Current Position

October 8, 2003

At the time of submission (October, 2003), I am finishing my Ph.D. requirements at Clemson University. I anticipate graduation in December, 2003. The postdoctoral position at Simon Fraser University that I am proposing here would hopefully begin in January, 2005. During the intervening time (Jan. - Dec., 2004), I have already been accepted as a postdoctoral fellow at Simon Fraser under the sponsorship of Peter Borwein. Michael Monagan and Petr Lisonek are co-advisors. Hence, the letter of invitation that I include is an explicit offer from P. Borwein; any funds promised in this letter, though, expire before the NSF postdoc begins. Also, since I will have more than one host at SFU, I have submitted Monagan's CV.