Mathematica Militaris

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Editor's Message

The use of computers to teach mathematics and to solve problems is highlighted in this issue. This is an area where the service academies have made great strides as evidenced by the presentations at the recent Joint Service Academy Conference on Computers in Mathematics (JSACCIM). See the article on this page for more about this conference, and read more about computing throughout this issue.

Now, on to more mundane subjects. The editorial staff needs volunteers to write book and software reviews. If you would like to help, let us know. We also encourage both faculty members and students to take part in solving problems from our Problems Section. To date, we haven't had any solutions to problems 1 and 2 of the first issue.

Our format is evolving. We have made it up to 8 pages; however, we have not used our desk-top publishing capability yet. Hopefuly, by the next issue, you'll see an elaborate desk-top publication. In the meantime, please enjoy our TEX version of *Mathematica Militaris*.

Computers in Mathematics

On 1 and 2 June, 1989, the United States Military Academy hosted the 2nd Annual Joint Service Academy Conference on Computers in Mathematics (JSACCIM). Participants in the conference included faculty from the Naval Academy, Air Force Academy, Coast Guard Academy, Merchant Marine Academy, U.S. Military Academy and the Naval Postgraduate School in Monterey, California. The first conference was held last year and hosted by USNA.

The focus of the conference was to allow an interchange of information (much as this publication is designed to do) on how computers are being used in the classroom to facilitate the learning of mathematics. The conference was divided into two half-day sessions. The first session focused on the tools that are available for help in teaching math. Each academy uses different software, and uses it in different ways. For instance, USMA is currently using Calculus Toolkit as a supplement to understanding some of the calculus concepts. USNA has developed their own software for teaching Calculus (Military Plotting Package, MPP) and Differential Equations (Midshipman Differential Equations Package, MDEP). The Naval Academy integrates their software completely into the courses by requiring students to do homework assignments using the software. Both of these programs are excellent. USCGA presented their own software, written for the Apple Macintosh series of computers, and USAFA showed their use of commercial packages called MicroCalc and MathCAD, as well as their own Symbolic Functions Response Package, which is designed to force students to answer test-type questions symbolically instead of choosing from multiple-choice answers.

The second half-day session focused on how the software and hardware shown during the previous session is actually used in the classroom. Each school discussed example problems, special problems and teaching techniques during their talks. Almost everyone handed out copies of typical homework assignments and special problems, such as case studies for probability and statistics courses and projects for numerical analysis.

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Curriculum

USNA

MPP (Midshipmen Plotting Program) is a multifaceted computer program developed by Professor Howard Penn, Associate Professor Craig Bailey, and Associate Professor Jim Buchanan to aid in the teaching and learning of calculus. It was originally intended as a function grapher that would take advantage of the EGA color monitors on Zenith microcomputers at the Naval Academy. It has since expanded to include modules on finding roots of equations, numerical integration for single, double, and triple integrals, contour plots, and vector fields. It has a screen-driven user interface with the ability to save and restore screens for faster classroom use. A series of computer assignments for Calculus I, II, III has been developed to help students better understand the topics they are studying through the use of the graphics available. Professor Buchanan has also developed a graphics package for use in differential equations courses.

Professor Mike Chamberlain has written a series of computer tutorials on probability and statistics. These tutorials have two major objectives. First, important concepts in elementary probability and statistics are illustrated with graphics screens and dynamic simulations. Second, midshipmen are required to run the tutorials on their own and submit written reports on what happened, what they learned, and how the software could be improved. The tutorials comprise about 20 lessons. In addition there is a utility program that computes probabilities and displays shaded histograms/densities associated with the following distributions: binomial, hypergeometric, negative binomial, Poisson, normal, Student t, gamma, exponential, c2, beta, Weibull, and F.

For more information on these programs, write to Professor Penn or Professor Chamberlain at the Department of Mathematics, United States Naval Academy, Annapolis, MD 21402.

USMA

The microcomputer allows graphic display, quick testing, and quick solution of models. That's the lesson that students in Mathematical Modeling—MA391—are learning. Using a variety of packages, homegrown, educational, and commercial, students are using software to solve problems that would have been impossibly time-consuming before the advent of easy access to computing.

MINITAB is used extensively for display of data, testing of explanatory models developed on paper, and fitting both explanatory and empirical models. MINITAB's ability to quickly manipulate data sets and display a graph of the results allows both instructors and students to experiment with different models and get a quick feel for the results. Students, while generally pleased with the abilities MINITAB gives them, tend to be frustrated with the package in two areas, the user interface and the disk swaps required when using the package on a two floppy machine.

Specific areas of the course, such as empirical modeling, also use simple Pascal routines to simplify the tedious computations required for such techniques as cubic splines. The routines, for which source code is provided, also reinforce the programming skills taught during the first year as they provide building blocks for the simulation project that forms one of the major course blocks.

Linear Algebra—MA371—is also using software packages to lessen the tedium of repetitive calculations and to allow students to solve problems that would have been impossible for students until recently. LINTEK, a series of

integrated routines available with the textbook *Linear Algebra* by Fraleigh and Beauregard, provides a relatively simple way for cadets to solve problems and see relationships develop in front of them, where previously they could only see "snapshots" of the process. The major advantage for cadets is the ability that LINTEK gives to manipulate matrices of a reasonable size instead of the "toy" sizes traditionally used.

USAFA

Over the last year considerable thought has been given to how we could best incorporate personal computers (which all cadets are required to purchase) into the mathematics curriculum. The "scratchpad" mathematics programs which have come out recently seem to us to be an ideal solution. Such products as MathCAD allow students to express themselves logically on the computer screen and to obtain nearly immediate graphical images of their solutions. We expect this to enhance their education in at least two ways—they should find the mathematics more relevant and interesting, and, they will be more productive in their upper level technical courses.

There are essentially four elements to our plan to incorporate MathCAD into our curriculum—instructor training, procurement of the product for the cadets, generation of suitable introductory problems, and followup. We gave two hours of instruction to current instructors and three hours to our new arrivals. We are requiring most new cadets to purchase the student version of MathCAD (approximately $40). Several introductory problems have been designed and will be assigned during selected courses in a very gradual fashion so that by the time cadets have completed their first differential equations course they will be reasonably proficient. Follow-up will be done throughout the first year to ensure we are obtaining the desired effect.

USCGA

We strive to incorporate some form of computation into each of the Mathematics courses. The projects assigned in most courses are not intended to be programming exercises. We give the cadets experience in using computers to solve engineering design or statistical research problems. Each project requires a report that would be similar to that required if the work was performed as part of a funded research project. The projects range from using computer output to graphing functions to performing statistical analysis.

In Calculus I, one of the projects requires students to enter derivatives they have calculated and then use computer output to graph complicated functions. Though they could use the computer to actually draw the graphs, the accuracy required in reporting critical points demands the use of a computer for analysis. The Calculus II course uses the computer and Simpson's method of integration along with Taylor and Maclaurin series to compute the displacement of various cutter and buoy hulls. This year we intend to incorporate *Mathematica*^{tm} into each course's project. Our Advanced Engineering Math course is using various fractal programs along with some programs developed by cadets to study chaotic behavior in systems.

Problems Section

Problem 3: Find a number, Q, with the property that by moving its right-most (last-place) digit to the left-most (first-place) digit, the resulting number is twice the original number Q.

Research and Consulting

USAFA

Stat Rats is a forum within the mathematics department for researchers to present and discuss research projects. The name is derived from the fact that many previous research projects emphasized statistical applications. However more recently Stat Rats has broadened to encompass all disciplines of mathematics including such diverse areas as differential equations, advanced probability, and operations research. Some of the presentations this year have included Capt Ron Baird, Kalman Filters; Lt John Haussermann (USN), Fractals and Chaos; LtCol Steve Schmidt, Design of Experiments; and Capts Kirk and Barb Yost, Logistics Planning. Stat Rats provides an excellent opportunity for peer feedback on continuing research projects and interests.

On another note, LtCol Mark Kiemele is working with the National Security Agency's National Computer Security Center in modeling and evaluating the security of distributed systems. Col Kiemele developed an automated, rule-based computer model that will determine the security rating of a computer network, given the security attributes and connectivity of the individual components in the network. His model has been applied to the Air Force Supercomputer Network.

USCGA

Research into the application of learning theory of finite automata to limited state neural networks is being done by LT Tim Henry along with faculty members at the University of Rhode Island. This research involves several different mathematical and computational disciplines combining to develop better learning algorithms for artificial intelligence. By controlling the examples a neural network is presented, a "teacher" in a supervised setting can control the way the network learns and classifies its environment. LT Henry is working to develop algorithms and network strategies that will provide optimal learning in both supervised and unsupervised environments.

An example of a model used in the research is the simulation of a robot that can perform a set of basic actions: move forward, turn left, and observe what is directly in front of it. The robot has little or no experience of the environment. Different learning algorithms are then tried as the robot does supervised and unsupervised walks. In supervised walks, the robot is told where to go. The robot walks about randomly when doing unsupervised learning. The accuracy and robustness of the robot's learned view of the environment through each algorithm is then compared. The robot is exposed to its environment again and tries to predict the outcome of its actions.

USMA

Recently, three members of the Department of Mathematics were awarded Academy-wide research positions for one semester of the academic year 1990–1991. Their project proposals were found to be among the best by a selection committee awarding 8 spaces and research funding for the year. CPT Jeff Arndt will evaluate various digital image data as sources for a large area Geographic Information System (GIS). He will be using a Sun workstation to perform computation and to produce graphical displays. MAJ Jack Kloeber's project is entitled "Enhanced Model of the Magnetic Induction Process." He plans on producing and validating a statistical model to predict the hardness of steel bars produced with a magnetic induction process. CPT Thomas Pijor will investigate combat modeling as a renewal

process. He will be modeling combat using techniques related to Markov chains and absorption states.

USNA

Mathematical research at the Naval Academy covers a broad spectrum of topics. This year the department was honored to have Professor Peter McCoy be the recipient of the Naval Academy Alumni Association Research Award.

Associate Professor Peter Turner's primary current research interests lie in numerical analysis/computation science and algorithms with a particular emphasis on computer arithmetic and the level-index number system which is a possible alternative to the standard floating-point arithmetic system used in computers. Work in this area has been on several fronts: the distribution of floating-point numbers and its implications for computer design, theoretical developments in level-index arithmetic and its application and implementation. The latter has resulted in a developing interest in computer routines for the elementary functions and in the use of parallel processing within scientific computing. Together with a former research student of his at Lancaster University, UK, he is developing software programs and a simulated hardware design for symmetric level-index arithmetic for the Distributed Array Processor.

Within the field of computer arithmetic there is great effort being devoted to a search for a better system of number representation and arithmetic to try and overcome the shortcomings of the floating-point system. The level-index system was originally developed by C. W. Clenshaw and F .W. J. Olver; Turner was invited to join their team in the very early days of the project. He has become one of the principal workers on level-index arithmetic; particularly on the implementational algorithm development side.

Assistant Professor Sonia M. F. Garcia's research interests are directed towards the application of the theory of mixed finite-element methods to the study of the behavior of approximated solutions for elasticity equations, Stokes equations, plate equations, and others. One current direction of her research concerns the development, analysis, and application of moving finite-element methods on moving grids for evolutionary partial differential equations. Dr. Garcia received a grant from the Naval Academy Research Council to conduct research in the summer of 1989.

Computers in Mathematics
Continued from page 1

One of the highlights of the conference was the banquet talk given on the first day by Dr. Richard Jenks of IBM. Dr. Jenks discussed his work and the work of others in the area of Symbolic Algebra software. He not only highlighted some of the intricate algorithms involved in producing Symbolic Algebra software, but also discussed how readily-available software such as this should and would impact on the way we teach mathematics. His talk was very informative.

Next year's conference will probably be held at the U.S. Air Force Academy. We hope to see you there!

If you have any questions about the conference, or wish a copy of any of the information or software that was handed out at the conference, please feel free to call LTC David Arney or CPT Joe DiGangi, USMA, at AV 688-4811 or Commercial 914-938-4811, or contact the representative from your Academy. Representatives are (USAFA) Major Richard Hanley; (USMMA) Prof. Albert Stwertka; (USNA) Prof. Howard Penn; (NPGS) Prof. Mostafa Ghandehari; and (USCGA) Prof. Ernest J. Manfred. —Joseph Digangi.

Who's Who

USMA

Professor George Rosenstein visited the Department of Mathematics during the 1988-1989 academic year. He is from Franklin and Marshall College, Lancaster, Pennsylvania. While at West Point, Professor Rosenstein taught Calculus and an elective course in the History of Mathematics. He is the chief-grader of the Advanced Placement (AP) Calculus Examination and played an important role in the development of the new core mathematics curriculum at USMA. A special part of his year at West Point was the research he conducted on the contributions in mathematics education made by several USMA Professors during the early 19th century.

Professor V. Frederick Rickey is the Distinguished Visiting Professor for 1989-1990. He recently arrived at West Point from his position at Bowling Green State University in Ohio. Professor Rickey is also interested in the history of mathematics and is helping write a history of the USMA Mathematics Department. He is conducting a seminar in the development of the Calculus for the faculty.

The previous Visiting Professors to the Mathematics Department have been: Ben Fusaro in 1987, James Walker in 1986, Maury Weir in 1985, Caroll Wilde in 1984 and 1979, Dix Pettey in 1984, Peter Zehna in 1983, John Kenelly in 1982, James Herod in 1981, Siegfried Lehnigk in 1978, and Isaac Schoenberg in 1977.

USNA

Associate Professor Peter J. Welcher has been a member of the Naval Academy's Department of Mathematics since 1979. Dr. Welcher received a Ph.D. in Algebraic Topology from the Massachusetts Institute of Technology in 1978. Since then he has become heavily interested in computers and Computer Science. Recently, he has directed the networking of 130 PC's in faculty offices and classrooms of the Math Department and the procurement of 14 Sun computers to which they are linked. The network is Ethernet, running TCP/IP and PC-NFS software. On his own time, he programmed a Lotus-compatible spreadsheet that is being sold in various forms as Gold Spread, Joe Spreadsheet, and # Cruncher. During a recent year's leave without pay, he and an assistant programmed a large number of statistical additions to the spreadsheet.

USCGA

Dr. Joe Wolcin came to the USCGA in August 1984 and has at one time or another taught every math course in the department. He received his doctorate in Engineering and Applied Science from Yale University in 1975. He first developed the theory for optimally detecting and tracking frequency modulated narrowband signals in noise, and then implemented the theory in a widely heralded computer algorithm called MAPLE (Maximum APosterioiri Line Extraction). The algorithm and its derivatives have important Navy related applications for threat detection, especially for very quiet targets.

He has developed algorithms for noise background equalization/normalization, transient signal detection and classification, and synthetic aperture analysis. Noise background equalization is used to prewhiten observed data in a variety of signal processing settings. The algorithm Dr. Wolcin developed for transient signal detection (MAXTRAN) is now the most highly regarded algorithm for transient detection. Synthetic aperture analysis works to coherently combine observations from a

moving sensor to gain the advantages of a long array of sensors.

USAFA

Colonel Daniel W Litwhiler, Head, Department of Mathematical Sciences, served his first tour at the US Air Force Academy as an Assistant Professor from 1972-1974. His second tour began in 1977, serving as Tenured Professor and Deputy Department Head until July 1985. After attending the Industrial College of Armed Forces, he returned to USAFA in July 1986 to take charge of DFMS. In 1982, Colonel Litwhiler departed USAFA to serve a one-year sabbatical assignment as an Issues and Policy Analyst and Speechwriter for the Secretary of the Air Force.

Colonel Litwhiler was born in Ringtown, Pennsylvania. He graduated with honors from Florida State University in 1963 with a BS in Mathematics and Mathematics Education. He received an MS in Mathematics from Florida State in 1965 and was commissioned 1 October 1965. From 1974 to 1977 he completed a PhD in Industrial Engineering/Operations Research at the University of Oklahoma.

Colonel Litwhiler's other military assignments were in Thailand directing operations at an Atomic Energy Detection Facility (1967-1969), in Oklahoma as Comptroller of Southern Communications Area (AFCC), and in Japan as a Programs Officer (1970-1972). His military decorations include four Meritorious Service Medals, the Joint Service Commendation Medal, two Air Force Commendation Medals, the Air Force Achievement Medal and the Vietnam Campaign Medal. He and his wife, Peggy, have four children.

Activities: USAFA

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During the summer of 1989 the following cadets participated in the program with the indicated organizations: C1C Robinson and C1C Ogawa, Space Division, Los Angeles Air Station; C1C Haines, Rome Air Development Center, Griffis AFB; C1C Finney, AF Engineering and Services Center, Tyndall AFB; C1C Hensley, AF Logistics Management Center, Gunter AFB; C1C White, OSD Program Analysis and Evaluation, Pentagon; and C1C Schubert, HQ USAF Studies and Analysis, Pentagon. This program gives the students an excellent introduction to their future work environment. This gives the students an opportunity to use their academic knowledge while learning how research is actually accomplished in a non-academic environment.

Editorial Staff

Subscription

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Activities

USMA

The USMA Mathematics Department sponsors the Math Forum. This extracurricular cadet activity provides a forum for the presentation and discussion of mathematics related concepts and applications outside the classroom environment. Membership is open to any interested cadet. The Forum is in the process of being designated as a Student Chapter of the Mathematical Association of America.

During this academic year the Forum has a variety of activities planned. We will compete in the Virginia Tech Regional Mathematics Contest in October and use these results to field a competitive team in the Putnam Mathematical Competition in December. We have educational visits scheduled to Rensselaer Polytechnic Institute, Watervliet Arsenal, Benet Weapons Laboratories, and the IBM Research Center. In the spring semester, we will spend a weekend in Washington, D.C. visiting various Army agencies and laboratories.

Furthermore, the Forum has monthly meetings which include a guest speaker who talks about a mathematical topic of interest. The Forum also sponsors a "problem-of-the-week" contest which is conducted through the Academy's electronic bulletin board.

USNA

In the fall of 1988 the Department of Mathematics requested and received funding from the Naval Academy Faculty Development Fund to run a seminar in applied mathematics. Twenty-four hourly seminars were held throughout the year. The main purpose of these seminars was to create a scientific atmosphere in which the latest mathematical techniques as applied to all areas of science can be discussed.

The lectures during the year included such areas of applications of mathematics as numerical methods for partial differential equations, parallel processing and computations, global modeling of weather, shear band formation in metals, artificial intelligence, elastic waves and homogenization, constitutive laws in composites, among several other topics.

These seminars were intended primarily for the faculty of the Naval Academy, although a few of the talks were directly targeted at midshipmen. Participants in these seminars included not only civilian and military members of the Mathematics Department and Mechanical and Aerospace Engineering Departments of the Naval Academy, but also several faculty members and graduate students of the Department of Mechanical Engineering at Johns Hopkins University, the Ballistic Research Laboratory, Catholic University, and the Department of Mathematics at the University of Maryland at College Park, among others. Another series of seminars is planned for the coming year.

USAFA

Every year the Mathematics Department selects the top ten percent of our third year students for the Cadet Summer Research Program (CSRP). In the summer between their junior and senior years, these students go to various defense agencies for six-week research projects.

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Special Thanks

We thank COLSA, Inc., Huntsville, Alabama, and the West Point Alumni Association for their support of *Mathematica Militaris*.