



Mathematica Militaris

The Bulletin of the Mathematics Departments of the United States Service Academies

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Editor's Message

This first issue of *Mathematica Militaris* is being distributed during the summer, since we missed our spring deadline. I'm sure many faculty members and students of the mathematics departments of the service academies are spread far and wide across the world. For many of you, the summer may be your busiest time of the year. In spite of all this activity, I hope you will find the time to read this first issue and find it interesting, informative, and a relaxing diversion from your other duties.

The primary purpose of *Mathematica Militaris* is to share information among the faculty and students of the mathematics departments of the four service academies: USMA, USNA, USAFA, and USCGA. While the missions of these departments are quite similar, each has different means of accomplishing its goals. By sharing information, we will be able to improve our programs by learning from each other. Hopefully, through *Mathematica Militaris*, these programs can develop a common identity, gain recognition, and build an effective communication link.

Please feel free to share your ideas with the Managing Editor from each academy or myself. We intend to make this a living entity which will evolve and grow as the needs change. *Mathematica Militaris* is your newsletter. This first edition was assembled hurriedly. Expect to see slightly larger and more refined issues three or four times per year.

Special Thanks

We thank the West Point Alumni Association for their support for this publication. We also

give special recognition and thanks to COLSA, Inc. of Huntsville, Alabama, and its president Francisco Collazo for their generous donation to the Alumni Association for the expressed purpose of funding *Mathematica Militaris*.

Software Review: "Derive, a Mathematical Assistant"

by Lt. Col. Robert Schumacher (USAF), Department of Mathematics, USMA

Derivetm, "A Mathematical Assistant", is a software system for simplifying, solving, and plotting mathematical expressions. This package is best classified as a moderately powerful entry level symbolic manipulator with reasonably friendly user interface. It also has a very good 2-/3-D plotting package. Derivetm can be used to produce classroom demonstrations of problems where currently the algebra involved prohibits presenting such problems. If the student has access to it, then Derivetm can be used to prepare case studies of practical problems.

Derivetm is an excellent tool for unloading the algebraic detail from the student and allowing calculus to be taught more at the conceptual level. This software package can be used to assist in solving problems where the tools of arithmetic, algebra, trigonometry, limits, summation, differentiation, integration, Taylor and infinite series, vectors, matrices, linear algebra, and others are involved. USMA will use Derivetm in several mathematics courses in the fall of 1989. Derivetm is a product of Soft Warehouse, Inc.

Note: We need volunteers to write reviews. If you would like to review a book or software package please notify the editor.

Curriculum

USNA—Focus on Curriculum

All midshipmen must take or validate three semesters of calculus and one semester of differential equations.

The standard calculus sequence is SM111-SM112-SM211, totaling eleven hours. There is also a slower-paced sequence SM101-SM102-SM201, totaling twelve hours. Yet another first-semester calculus course is SM100, a five hour-course which also includes topics from trigonometry and analytic geometry. Midshipmen completing SM100 continue with SM102. Midshipmen are tested upon entrance to the Academy to place them in one sequence or another. The first-semester calculus courses are SM101 AND SM111, low- and high track, respectively (four hours each). Mids are placed in one or the other of these courses according to their performance on evaluation tests on entering the Academy or according to performance in previous math courses. Other first-semester calculus courses are SM100 and SM161, a five-hour course which includes Pascal programming. Mids who take SM161 and its sequel SM162 needs not take the two-hour programming course required of everyone else.

The second-semester calculus courses are SM102 and SM112, low- and high-track four-hour courses, as well as the five- hour course SM162.

The third-semester calculus courses are SM201 (low-track, four hours) and SM211 (high-track, three hours). There is also SM201P (four hours), which is not low-track but rather for entering plebes who validate two semesters of calculus. We also have SM251 (four hours), a sequel to SM162.

The differential equations course taken by most mids is SM212. The low-track-high-track distinction does not exist at his level. There is also SM222, a differential equations course

required of mathematic majors and which uses concepts from linear algebra. All our differential equations courses are four-hour courses.

We now use the Second Alternate Edition of Earl Swokowski's CALCULUS WITH ANALYTIC GEOMETRY for all our calculus courses. The text used last semester for SM212 is Kent Nagle and Edward Saff's FUNDAMENTALS OF DIFFERENTIAL EQUATIONS.

Beyond these required core courses, by far the most popular math course is SM311, Engineering Mathematics I. This course treats a variety of topics, including some from linear algebra, vector calculus including Stoke's Theorem and the Divergence Theorem, and solving boundary value problems using sequences of orthogonal functions in one or several variables. The text is ADVANCED ENGINEERING MATHEMATICS by Erwin Kreyszig.

USMA

The four core mathematics courses taken or validated by all cadets was changed this year to include MA 101 (Calculus I), MA 102 (Calculus II), MA 207 (Differential Equations), and MA 208 (Probability and Statistics). The text used in MA 101 and MA 102 is *Calculus* by S. L. Salas, E. Hille, and J. T. Anderson. Nearly ten percent of the plebes take MA 100 (Precalculus Mathematics) before beginning the core sequence. Cadets selecting fields of study in science and engineering take one or more additional mathematics courses such as MA 361 (Multivariable Calculus with Matrix Algebra), MA 372 (Discrete Mathematics), and MA 484 (Partial Differential Equations). Cadets in several disciplines such as economics, system engineering, and engineering management take MA 391 (Mathematical Modeling) or MA 371 (Computational Matrix

Algebra) making these very high enrollment electives. Also new this year was the several lessons in MA 207 devoted to difference equations. An ongoing study is being conducted to expand this topic and move its presentation into the first core course. Another study is underway to teach a “lean and lively” calculus sequence.

USAFA

The most significant curriculum change in USAFA history is effective beginning with the class of 1990. Underlying this change was a reduction in core courses and a increase in majors courses. There are now only three core mathematics courses: Math 141 (Calculus I), Math 142 (Calculus II) and Math 220 (Probability and Statistics). Math 151 and Math 152 are honors versions of Calculus I and II. Also, those cadets majoring in selected science and engineering disciplines substitute Math 357 (Probability and Statistics) for Math 220. Math 243 (Calculus III), Math 245 (Differential Equations and Matrices), and Math 346 (Engineering Math) are large enrollment service courses intended for cadets majoring in the basic sciences and engineering. Finally, Math 340 (Discrete Mathematics) has growing enrollments, particularly as a requirement in computer science, and Math 343 (Computational Matrix Algebra) is commonly taken by cadets majoring in operations research or in certain engineering fields. In all core and service courses in mathematics, the microcomputer is increasingly used as a learning tool.

USCGA

The Mathematics Department makes a special effort to show how a formal education in mathematics can benefit a military career. All courses offered by the department stress relevant applications whenever possible. Com-

puter projects are required in most courses, and the computer is used as a source of ideas and for visualization. The department offers diverse opportunities so that cadets can engage in mathematics via projects, research, teaching, problem solving, or independent study.

Currently, considerable discussion is taking place in the United States on calculus courses taught in the first two years. There is concern with the high percentage of students that either fail or withdraw from these courses. The national average is between 30 to 35 percent. At USCGA, the figure is between 8 to 10 percent. This success rate is attributable to the dedication of the instructors and the mathematics placement program under the direction of LT George Rezendes. Cadets take a summer review course which enables the department to identify weaknesses and to address deficiencies in an Introduction to Calculus Course. Calculus II is offered during the summer to enable these cadets to catch up with the rest of their class.

Problems Section

Readers are invited to submit proposed problems with solutions or solutions to previously published problems directly to the editor. Try your hand at these problems.

1. This type of problem is called an alphametic and is solved by a one-for-one substitution of digits for the letters so that the sum is correct. For starters try this simple, but classic alphametic.

$$\begin{array}{rcccccc} & W & R & O & N & G & \\ & W & R & O & N & G & \\ \hline & R & I & G & H & T & \end{array}$$

2. Write a sum of positive integers in a geometric progression starting with 1 so that the sum is a square number.

Research and Consulting

USAFA—Focus on Research

A recent book on UNDERSTANDING DESIGN EXPERIMENTS by Lt. Col. Stephen R. Schmidt is being used to educate engineers and statisticians across the country in modern methods of experimentation and variability reduction. The text includes classical methods, Taguchi methods and a blending of the two. The course he developed (which parallels the book) has been used by several universities (graduate and undergraduate), numerous DoD contractors, the Defense Systems Management College, and various agencies throughout the DoD acquisition community.

Lt. Col. Tony L. Mitchell developed an easily expandable, fault-tolerant, self-routing computer network topology for connecting computers aboard NASA's planned space station. The topology has received national and international attention as Lt. Col. Mitchell presented numerous original papers at professional computer and communication conferences. Military Airlift Command, Strategic Air Command and Tactical Air Command are currently evaluating Lt. Col. Mitchell's proposal for a Super Military Network (SUPMILNET) using his new topology.

The Department of Mathematical Sciences also has several individuals testing and validating the Acquired Immune Deficiency Syndrome (AIDS) Model under the direction of Lt. Col. Thomas F. Curry. The model is being developed in a cooperative effort by the Bureau of Census, Los Alamos National Laboratory, and Merrian Laboratory (University of Illinois).

USCGA

Dr. Joseph J. Wolcin has been involved in numerous consulting efforts in sonar signal pro-

cessing with the U.S. Navy. The following summarizes his recent efforts: (1) Synthetic Aperture Processing. When a target emits only low frequency energy, it is difficult to estimate the targets bearing, without using an extremely long array of sensors. An approach was developed to accomplish this task by combining observations from a moving array. (2) Array Gain Study. An algorithm was written to evaluate the array gain of an arbitrary volumetric array of sensors in an arbitrary noise field. (3) Sequential Detection Applications. Sequential hypothesis testing procedures were used to develop algorithms for both passive and narrowband signal detection. Both algorithms use dynamic programming to search for possible detections. (4) Transient Signal Detection and Classification. Generalized likelihood ratio testing procedures were used to develop algorithms for both detection and classification of transient signals. (5) Focused Beamformed Processing. Algorithms to find the maximum likelihood of target path using focused beamforming outputs were developed.

USMA

Several faculty members including LTC David Arney, LTC Lee Dewald, MAJ Gary Krahn, CPT William Ebel, CPT Charles Kennedy, and Dr. Joseph Arkin have been investigating several classic problems in combinatorics and number theory. Their efforts have concentrated on developing new results and formulas for relationships in sequences of integers (i.e., Fibonacci Numbers) and discovering new arrays of numbers with special properties. This work has resulted in recent publications in the *Fibonacci Quarterly* and *Journal of Recreational Mathematics* and presentations at several meetings of the American

Mathematics Society.

MAJ John S. Robertson is a co-principal investigator under a research grant from the Ocean Acoustics Branch of the Office of Naval Research. Together with colleagues at Rensselaer Polytechnic Institute, MAJ Robertson studies mathematical models of underwater sound propagation. He is interested in a model called the "parabolic approximation" which is widely used to predict the behavior of low-frequency sound waves in the ocean. He is also involved in research projects with both the Army and NASA which involve application of this underwater model to problems in atmospheric acoustics.

USNA

Our department comprises about fifty civilians and twenty military personnel. Most of the civilians and many of the military actively pursue a research program. Here are introductions to just a few of these.

Assistant Professor John F. Pierce's research efforts are currently directed towards the application of the theory of bifurcation to the study of the behavior of nonlinear mechanical systems possessing symmetry. His principal focus has been on identifying and characterizing the buckled configurations on nonlinearly elastic columns which originally possess a cylindrical symmetry.

Associate Professor Michael Hoffman's research interests include algebraic topology, geometry, and group theory. He is currently pursuing a research problem involving the algebraic characterizations of those 2-groups that can act freely on certain product spaces. This is part of a broader program of studying spaces that are 'rigid' in the sense that their rational cohomology determines the possible fixed-point-free self-maps they can have: many classical homogeneous spaces (e.g., complex Grassmann manifolds) appear to be 'rigid' in

this sense.

Associate Professor Carol Crawford conducts her research in pure and applied graph theory and combinatorics. Part of her work applies graph theory to robot vision system design. This research is part of cooperative projects with the Johnson Space Center, David Taylor Research Center and the National Institute of Standards and Technology. Dr. Crawford also publishes papers on Chromatic Polynomials, a topic in theoretical graph theory.

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Name:	_____
Address:	_____

Activities

USMA

Cadets Ivan Pineda ('90), Eric Chibnick ('90), William Acheson ('90), David Biersach ('89), Larry Schauer ('90), Steven Tullis ('90), Geoffrey Jeram ('92), and Han Nguyen ('92) participated in the 5th Mathematical Competition in Modeling. A team of three cadets worked on a model for airport runway scheduling while the other team modeled insect classification. The two plebes were alternates who participated in the training sessions.

6 cadet members of the Mathematics Forum visited the Mathematics Division of IBM's Watson Research Laboratory on 22 March and were briefed on several interesting problems being considered by mathematicians.

USMA hosted the Seventh Army Applied Mathematics and Computing Conference on 6-9 June 1989. Over 75 mathematicians and scientists presented papers on research projects of interest to Army laboratories.

USNA

Ten midshipmen from the Naval Academy participated in the Tenth Virginia Tech Regional Mathematics Contest. The top finishers were Eyo Ita ('90) with a score of 49, Mark McCulloch ('92) with 43, Emmett McCarthy ('91) with 30 and Mark Dixon ('90) with 26.

The Naval Academy's participation in this year's William Lowell Putnam Mathematical Competition was its most successful since the mid-seventies. This year the Naval Academy ranked 45 out of 360 institutions. The team consisted of Mark Dixon ('90), Eyo Ita ('90), and Marc Lucas ('91), who scored 24, 30, and 31, respectively. The other participants, Stephen Kline ('90), Dianne Leroux ('90), and Joseph Luchtenberg ('90) finished with quite respectable scores of 15, 11, and 21.

USAFA

All of the Air Force Academy's top performers in this year's annual Putnam Exam Competition were fourth classmen. Cadet Eric Orrill turned in the best performance with a score of 29. He received national recognition. Other strong finishers were Cadets Hassan Dehmani (20), Vincent Chioma (15), and Nathan Allheilgen (14).

Cadet Phil Mayfield ('89) presented his research findings on computer network security at the MAA's Rocky Mountain Section meeting. His presentation, "A Matrix-Checksum Approach to Computer Virus Detection" represented his study under the guidance of Lt Col Mark Kiemele. Phil was recognized at the meeting as one of top student speakers.

USCGA

This past semester, 1/c Melinda Dalrymple placed second at the Forty-Third Annual Eastern College Science Conference for her research entitled Optimal Path Determination. The Mathematics Department in conjunction with the Mathematics Association of America sponsors the United States Mathematics Olympiad Contest for the state of Connecticut. Winners of the competition form a national team and compete in the International Olympiad Contest. The State winners and their parents were invited to the Academy for an awards ceremony. Lt. William McHenry, who is responsible for the program, presented a paper on the contest at the University of Nebraska this spring.

In February, the Mathematics Department entered a team in the Math Modeling Competition. The Academy team received an Honorable Mention for their solution. Dr. Joseph Wolcin was the faculty advisor for the project.