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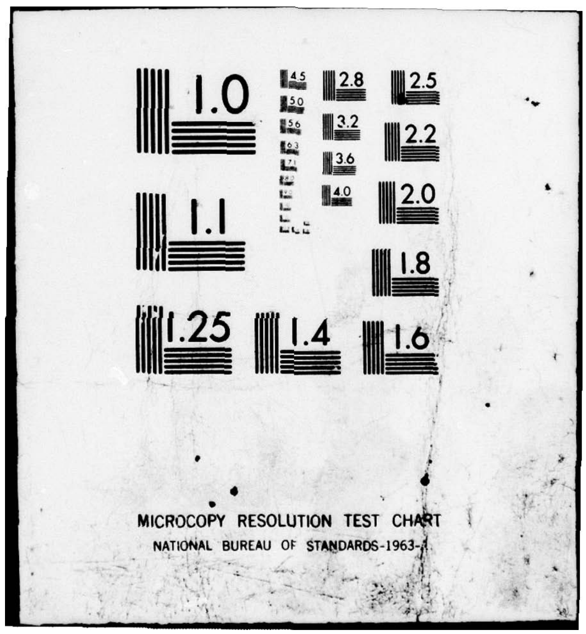
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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

USE OF MACSYMA IN THE NAVY LABORATORY RESEARCH COMMUNITY

(Jan 1977 - Jun 1978)

by

L. Kenton Meals

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COMPUTATION, MATHEMATICS, AND LOGISTICS DEPARTMENT
DEPARTMENTAL REPORT

July 1979 DTNSRDC/CMLD-79/09

USE OF MACSYMA IN THE NAVY LABORATORY RESEARCH COMMUNITY (Jan 1977 - Jun 1978) DTNSRDC/CMLD-79/09

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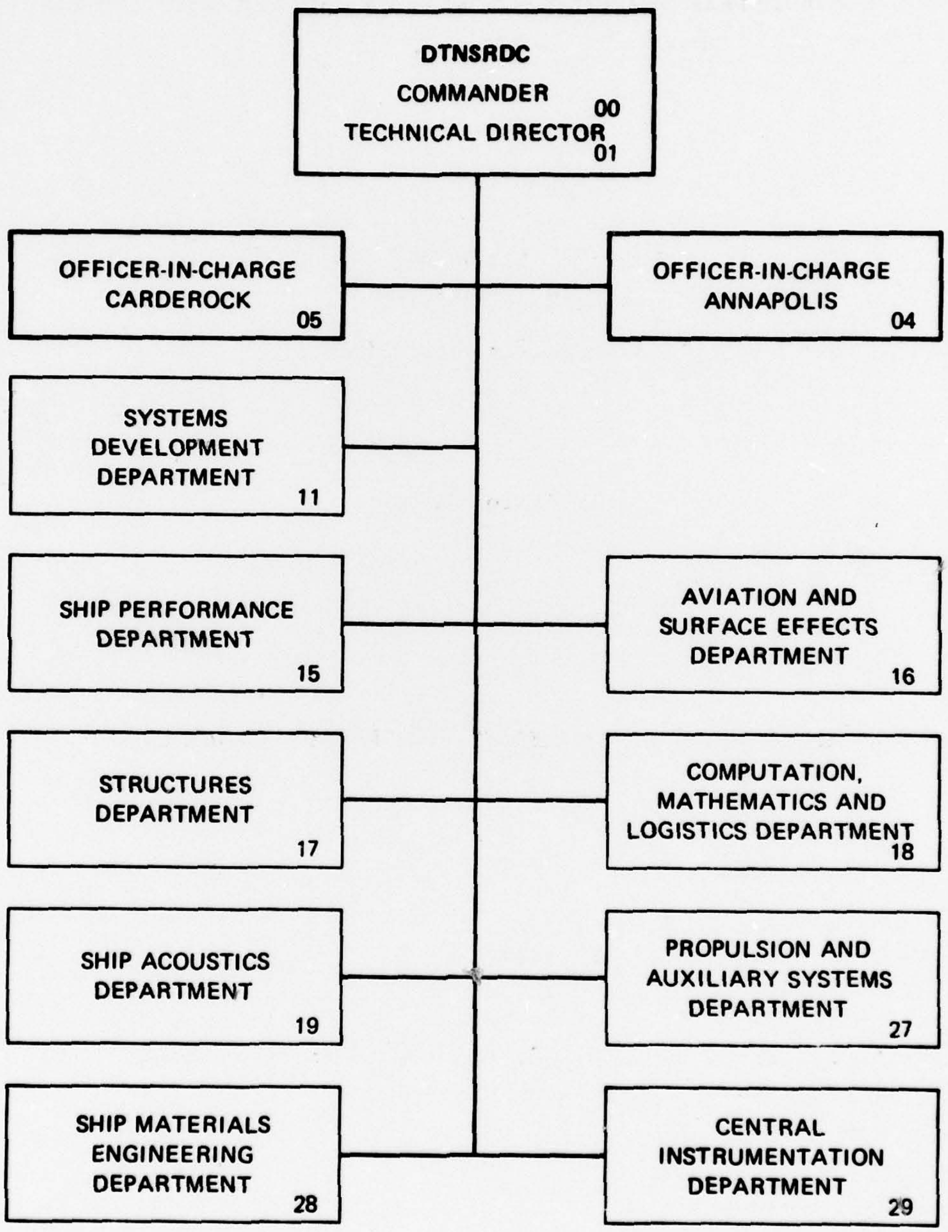

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MACSYMA, an interactive computerized symbolic manipulation system, is discussed in relation to its capabilities, its usage in the Navy Laboratories, and its demonstrated benefits to the scientific/engineering community. Specific applications in five laboratories are given and investigators are identified. Recommendations are made for continuation of support to broaden and refine the use of MACSYMA in the Navy Laboratories and to exploit the combination of symbolic and numeric computation on Navy Laboratory computer

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network facilities. Interest by Army and Air Force research groups in joining Navy's participation in MACSYMA is discussed and a recommendation is made for consideration to be given to making Navy a focal point in the Department of Defense for the use of MACSYMA.

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ABSTRACT

MACSYMA, an interactive computerized symbolic manipulation system, is discussed in relation to its capabilities, its usage in the Navy Laboratories, and its demonstrated benefits to the scientific/ engineering community. Specific applications in five laboratories are given and investigators are identified. Recommendations are made for continuation of support to broaden and refine the use of MACSYMA in the Navy Laboratories and to exploit the combination of symbolic and numeric computation on Navy Laboratory computer network facilties. Interest by Army and Air Force research groups in joining Navy's participation in MACSYMA is discussed and a recommendation is made for consideration to be given to making Navy a focal point in the Department of Defense for the use of MACSYMA.

INTRODUCTION

A particularly effective way in which the power of the computer can be brought to bear on scientific and engineering applications is through the use of symbolic algebraic manipulation techniques. Recent developments have made these techniques highly practical for Naval scientists.

Development of symbolic manipulation software dates from the early 1950's when symbolic differentation was first performed on the Whirlwind computer at MIT and on the UNIVAC I. In 1964, when the FORTRAN preprocessor called FORMAC was released by IBM, interest in the use of symbolic manipulation was intensified. Activity in FORMAC applications increased rapidly until IBM withdrew its support in 1970. FORMAC is still being used in many places, primarily in Europe. There are a number of other symbolic manipulation systems, some conceived as early as FORMAC, that have been or are still being developed. Some of these are intended for specialized applications, others are more general. Among the better known general systems are MATHLAB,[1,2*] REDUCE,[3] SCRATCHPAD,[4,5,6] ALTRAN,[7] SAC-1,[8] FLAP,[9,10] and MACSYMA.[11] MACSYMA is one of the most versatile and best maintained systems, and is available to all Navy laboratories through the Navy Laboratory Computer Network (NALCON).

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*A complete listing of references is given on page 26.

MACSYMA has been described as an automated mathematical co-worker. One of the objectives in developing the MACSYMA system was to demonstrate to what extent the concept of an automated mathematical assistant could be exploited. MACSYMA, Project MAC's SYmbolic MAnipulation System,[11,12,13,14] is the outcome of the results of two doctoral dissertations[15,16] written in 1967 combined with ideas in the MATHLAB[1,2] algebraic manipulation system. It is an interactive system that can currently be accessed through the ARPANET (Advanced Research Project Agency of the Department of Defense NETwork) from a wide variety of terminals. It is operating and being maintained on the PDP-10 at the Massachusetts Institute of Technology by the MATHLAB Group of the Laboratory for Computer Science (formerly Project MAC).

Even though MACSYMA is an extremely useful and versatile system, it is continually being extended and upgraded by incorporating more efficient algorithms as they become available and by extending its capabilities. The system is so designed that such changes may be made without interfering with its productive use or inflicting undue hardships on its users. An effective built-in communication system keeps users informed as improvements are installed.

Many who use MACSYMA are convinced that it has opened a new dimension of scientific computing, and they can point to problems they have solved that would have been impossible or impractical without the aid of such a symbolic manipulation software system.

CAPABILITIES OF MACSYMA

The MACSYMA system is made up of a number of modules which perform specific functions and are linked together through a control program. Figure 1 illustrates this structure. This rather loose structure allows the modules a certain amount of independence and facilitates the continuing upgrading of the system through improvement of algorithms and expansion of capabilities. Capabilities of the MACSYMA system as of May 1978 are as follows:

a. Variable precision fixed and floating point arithmetic.
Fixed point and rational arithmetic is of unlimited precision. Floating point arithmetic allows the precision to be specified by the user and provides a set of numerical routines for computing functions such as logarithms, exponentials, trigonometric functions (in real or complex arithmetic).

b. Two-dimensional display of expressions.
The expressions are displayed on the output device (e.g., teletype or display screen) in a form very much like that used in textbooks. This is particularly advantageous for reading results of symbolic operations involving symbols requiring more than one line of printing in a textbook.

c. Rational function manipulation.
MACSYMA provides for all the ordinary algebraic operations with rational functions as well as providing for substitutions, simplifications, and differentiation. The most vital element in rational function manipulation is the Greatest Common Divisor Algorithm. The one used in MACSYMA is the most efficient of the various existing algorithms in a wide variety of cases.

d. Trigonometric function manipulation.
Among the features of the trigonometric function manipulation capability are provisions for giving the exact values of specific angles, conversions of multiple angles to single angles and vice versa, conversion from trigonometric to exponential form and vice versa, and incorporation of other knowledge about trigonometric, arctrigonometric and hyperbolic functions.

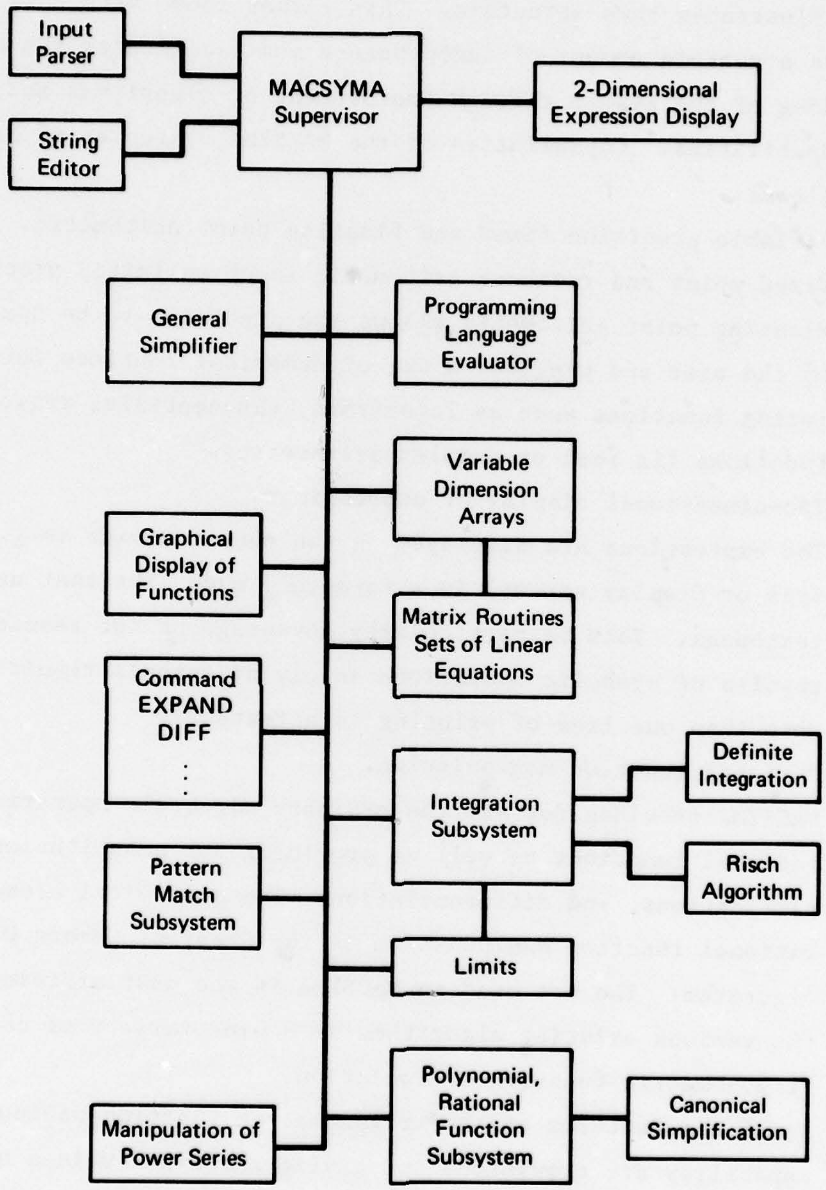

Figure 1 - MACSYMA Structure

e. Power Series manipulation.

Provision is made to expand functions of a single variable into Taylor series or Laurent series. Provision is also made for expansion of multivariate functions into Taylor series whether the variables are independent or interdependent.

f. Matrix manipulation.

All the usual matrix operations are provided including finding determinants, inverses, characteristic polynomials, and solving systems of linear equations. There are certain practical limitations on the symbolic matrix manipulations. Care must be exercised, for instance, in the case of matrix inversion, where the form of the matrix to be inverted can substantially affect the effort required. One user abandoned trying to get a general solution to his problem where the inversion of his sixth order matrix overtaxed the system.

g. Integration subsystem.

For a fairly large class of expressions, the system will find an indefinite integral if one exists. This class includes rational functions and more general elementary functions. The system also computes limits and gives definite integrals of various classes of expressions.

h. Factorization of polynomials.

Polynomials can be factored over both the integer field and the complex number field.

i. Pattern matching.

The pattern matching functions in MACSYMA provide a facility for testing expressions for combinations of syntactic and semantic patterns and automatically setting variables to parts of expressions that fit the pattern. This allows the user to transform an expression as well as see if it fits a pattern. It is also possible to set up rules for simplification of functions or operators and make the choice of rules dependent on a pattern match of the operands of the expression to be simplified. Using the pattern matching facilities of MACSYMA effectively is not easy to master but it can be a great aid in handling complex problems.

j. Noncommutative operations.
Noncommutative operators such as gradient, cross-product, etc., can be handled by MACSYMA.

k. Tensor manipulation.
There are two types of symbolic tensor manipulation available. Explicit tensor manipulation requires the tensor to be represented as arrays and performs operations on the components. Indical tensor manipulation allows the tensors to be represented as functions of their covariant and contravariant indices and performs operations on the tensors by manipulating the indices rather than the components.

l. Laplace and inverse Laplace transforms.
There is a variety of functions for which these transforms can be taken. This capability may be extended to include various other transforms as part of the continuing development of MACSYMA.

m. Special Functions.
Many of the symbolic manipulation routines can be applied to the error function and the gamma function directly. There are numerical routines for evaluating a variety of special functions for specified arguments.

n. Plotting.
MACSYMA has exceptionally versatile two and three dimensional plotting capability on CRT terminals such as the Tektronix. There is also provision for plotting output on teletype-like devices. Most of the standard plotting forms are included.

o. Series summation.
The closed form sums of series can be obtained for most common cases.

p. Definition of functions.
MACSYMA has provision for users to define functions and to write commands in a language similar to ALGOL which is convenient and easy to read.

q. String and list processing.

MACSYMA allows users to manipulate information as strings and lists.

r. FORTRAN output.

Output of algebraic expressions can be produced in a format acceptable to a FORTRAN compiler. This permits entire FORTRAN programs to be generated by using string processing.

s. Interactive capabilities.

Some of the advantages of any good interactive system are reasonably rapid response time, validity checking of input by the system, intelligible error printouts, ability to make changes readily, and provision for storage and retrieval of information with ease. MACSYMA provides all of these except, at times, the first which is dependent on the network traffic and system load. Because MACSYMA is constantly being upgraded, information of general interest to users is stored as a series of system messages which the user is given the option to see anytime he uses the system. Another means of communication via the system is available in system mail, whereby one user may address a message to another user who will then receive it the next time he logs onto the system. Still another method for users to communicate with each other is through "on line" communication where two users who are logged in may type messages directly to each other. It is by this means that MACSYMA system programmers at MIT offer immediate assistance to users who are having trouble.

t. Continuing system maintenance.

The MACSYMA system operates on and is maintained on the computers at MIT by the MATHLAB group of the Laboratory for Computer Science. Staff members are continuing to do research on the system, upgrade the system, and monitor the use of the system. There is always a system programmer available to give assistance through the communication channels of the ARPANET.

USE OF MACSYMA IN NAVY LABORATORIES

GENERAL COMMENTS

In June 1976, a survey was conducted in the ten Navy laboratories participating in the Navy Laboratory Computer Network. The survey showed that only two of the laboratories, David W. Taylor Naval Ship Research and Development Center (DTNSRDC) and Naval Research Laboratory (NRL), had personnel who were using or had used the MACSYMA system. However, there were personnel at the Naval Surface Weapons Center, both at White Oak, Maryland (NSWC/WO), and at Dahlgren, Virginia, (NSWC/DL) as well as personnel at DTNSRDC and at NRL who had some knowledge and experience with symbolic algebraic manipulators other than MACSYMA.

In January 1977 a report was issued recommending that NALCON undertake an experiment to determine the benefits of making MACSYMA available to the Navy Laboratory Community.[17] In April 1977 the NALCON MACSYMA Usage Experiment (page A5, Appendix A) was initiated and in July 1977, NALCON became a member of the MACSYMA Consortium for the period of one year. The first MACSYMA Users Conference was held at the University of California in Berkley, July 27-29, 1977 with 89 attendees.[18] There were four attendees from the Navy Laboratories, two of whom presented papers.[19,20] An account of this conference including the titles and authors of the 46 papers that were presented appears in Appendix A, pp. A6-A10 inclusive. Abstracts of the two papers by Navy authors appear in Appendix A, pp. A13 and A14.

In October 1977 the first NALCON MACSYMA newsletter (Appendix A) was issued and 76 copies were initially distributed to a representative list of recipients for the Navy Laboratories. Additional copies were distributed as requested. In December 1977 the first questionnaire to survey NALCON MACSYMA usage was sent to each person who had used MACSYMA via NALCON prior to 1 December 1977. The survey form with a composite of the 10 responses appears in Appendix B, pages B5-B11 inclusive.

A three-day course in MACSYMA was held at the David W. Taylor Naval Ship Research and Development Center on February 6 through February 8, 1978 with 35 attendees. Four of the Navy Laboratories were represented.

The course was team taught by two members of the Mathlab group, Laboratory of Computer Science, MIT. A summary of the course is included in Appendix B, pages B2 through B4.

A second usage survey questionnaire was mailed in February 1977 to each person who had used MACSYMA via NALCON during the period from 1 December 1977 through 31 January 1978. A composite of the 15 individual responses to this questionnaire is included in Appendix C, pages C3 through C7. Use of MACSYMA for the course was treated separately in the usage summary (Appendix D, p. D1).

In March 1978, the second NALCON MACSYMA newsletter (Appendix B) was issued with an initial distribution of 103. In April 1978 the third user survey form was mailed to each of the 25 individuals who had used MACSYMA via NALCON during the period from 1 February through 31 March. Responses are summarized in Appendix D.

Table 1 gives a profile of NALCON MACSYMA usage from January 1977 through June 1978. An upward trend in the number of users per month is evident with a significant increase that can be attributed to the MACSYMA course in February. The number of current active users represents the number of distinct NALCON users who logged into MACSYMA during the designated month. This number includes about a half-dozen steady users who utilize the system every month and a group which changes in makeup from month to month because of the sporadic needs of its members.

TABLE 1 - NALCON MACSYMA USAGE

MONTH	Number of NALCON Users in MACSYMA System	Number of Active NALCON Users in Current Month	Total Connect Hours	Total Run Minutes
1977				
Jan.	8	6	292	164
Feb.	10	7	190	112
Mar.	10	7	479	412
Apr.	10	6	328	342
May.	10	6	252	94
June	10	7	196	76
July	9	5	117	41
Aug.	9	7	200	68
Sept.	10	8	172	106
Oct.	11	9	407	388
Nov.	13	10	451	734
Dec.	17	13	368	366
1978				
Jan.	18	11	238	83
Feb.	29	22	358	186
Mar.	33	22	307	125
Apr.	36	20	263	185
May	36	15	228	210
June	37	15	446	586

APPLICATIONS BY LABORATORY

Five of the Navy laboratories have reported the application of MACSYMA either directly of indirectly to the solution of Navy problems. Some of this work has been formally reported in publication[19,20,21,22,23] and some in presentations (Appendix B, p. B13, Appendix C, pp. C8,C9). The remainder have been informally reported in response to the surveys of MACSYMA users. These applications are catagorized by laboratory and application area in the following pages.

Applications at David W. Taylor Naval Ship
Research and Development Center

1. Structural Analysis

- Computation of symbolic integrals and polynomial coefficients for nonlinear structural analysis.
  Investigator: Myles Hurwitz, Code 1844

- Analytic solution of a plane stress problem for a plate with holes and reinforcements.
  Investigator: Myles Hurwitz, Code 1844

- Development of B-spline representations of curves and surfaces for use with a data generator for finite element analysis.
  Investigator: Dr. Feodor Theilheimer, Code 1802

- Generating and plotting of biharmonic function and solutions to boundary value problems involving biharmonic equations arising in the structural analysis of reinforced plates with holes.
  Investigator: Dr. E. Cuthill, Code 1805

2. Structural Test Planning

- Checking of a proposed method for placing sensors on a structure test model by calculation of ASEM loads from a set of measured strains.
  Investigator: Ralph Johnson, Code 187

3. Acoustics

- Calculation of target strength reduction due to compliant coatings on plates
  Investigator: Dr. Thomas Eisler, Code 19

- Study of acoustic radiation from structures with ribs
  Investigator: Dr. Thomas Eisler, Code 19

- Study of attenuation of turbulent boundary layer noise by acoustic blanket
  Investigator: Dr. Thomas Eisler, Code 19

4. Logistics

- Symbolic solution of a set of balance equations arising from a queueing-network representation of a computer system
  Investigator: Dr. George Humfeld, Code 187

5. Aerodynamics

- Trial usage to investigate the applicability of MACSYMA to the development of helicopter blade dynamic equations of motion
  Investigator: Peter S. Montana, Code 1619

6. Graphic Display

- Generation of graphs for presentation and inclusion in report
  Investigator: Dr. George Humfeld, Code 187

- Development of a specialized graph paper to be used in the prediction of battery life
  Investigator: Dr. George Humfeld, Code 187

7. Computer Program Development

- Performance of tedious algebra required to produce computer programs for the CDC 6600 in interactive graphics and fluid flow
  Investigator: Mel Haas, Code 1843

- Solution of transformation equations used in a data base display system
  Investigator: Richard Van Eseltine, Code 1843

8. Numerical Methods

- Generating approximate solutions to differential equations, in particular, solving boundary value problems using Galerkin and Least Squares methods
  Investigator: Dr. E. Cuthill, Code 1805
  L.K. Meals, Code 1826

- Generating approximations to e^{-x} valid on an infinite interval
  Investigator: Dr. E. Cuthill, Code 1805

- Generating high order difference equations used in research in the study of turbulence phenomena
  Investigator: Dr. E. Cuthill, Code 1805

- Generation of difference equations for operator compact implicit methods for parabolic equations.
  Investigator: Dr. E. Cuthill, Code 1805

Applications at Naval Research Laboratory

1. Wave Propagation

- Study directed toward finding intensity statistics for a multiple-scatter model of wave propagation through a random medium
  Investigator: Dr. W.S. Ament, Code 5404

- Study of scattering by corrugated dielectric surfaces
  Investigator: Dr. W.S. Ament, Code 5404

2. Bifurcation Theory

- Solution of the Lyapunov-Schmidt branching equation in bifurcation theory using symbolic techniques
  Investigator: Dr. Abraham Schultz, Code 7932

3. Data Processing

- Development of a least squares processor for gated satellite altimeter echoes
  Investigator: Dr. W.S. Ament, Code 5404

4. Mathematical Modeling

- Manipulation of ordinary differential equations to be used in a large numerical model of two-dimensional reactive flows in the study of ignition and flame spread
  Investigator: Dr. Walter Jones, Code 6750

Applications at Naval Coastal Systems Center

1. Electromagnetic Theory

   - Solution of an eight by eight linear system arising in an electromagnetic boundary value problem
     Investigator: Dr. Michael Wynn, Code 792

2. Mathematical Tools

   - Checking the manual evaluation of a complicated contour integral
     Investigator: Dr. Michael Wynn, Code 792

   - Solution of differential equations and evaluation of integrals
     Investigator: John F. MacDonald, code 753

3. Software Development

   - Development of software for the PDP-11 and simulation of PDP-11 performance prior to hardware acquisition
     Investigator: Paul Bishop, Code 751

Applications at Naval Weapons Center

1. Electronic Networks

- **Solution of electronic engineering network problems and analysis of electronic circuits. Specific circuits for Navy Applications were analyzed. A few representive circuits are those for general amplifier using an accurate "emf source" model for a transistor, Wein bridge oscillator, and for double tuned transformer. Some of the circuits would have required 160 hours of error free hand calculations to analyze. A sample circuit analysis was prepared for distribution to electronic engineers who could benefit from the MACSYMA approach.**
  Investigator: John G. Richer, Code 3134

- **Analysis of circuits of the Sidewinder missle control system**
  Investigator: Gerald E. Powell, Code 3621

Applications at Naval Underwater Systems Center

1. Training

- Preparation of a 45-60 minute presentation demonstrating the capabilities of MACSYMA for NUSC applications.
  Investigator: R. Drew Drinkard, Code 4424

BENEFITS FROM MACSYMA USAGE IN THE NAVY LABORATORIES

EXTENDED ANALYTICAL CAPABILITY

The ready access to reliable automatic symbolic mathematical manipulation provided by MACSYMA allows Navy scientists and engineers to solve problems that would be otherwise impossible or impractical. Such problems characteristically require long tedious mathematical operations to solve and often are numerically unstable or require excessive computation for numerical solution.

Some of the problems solved using MACSYMA in the Navy laboratories were of this nature. They include:

- Symbolic solution of sets of balance equations from a queuing-network representation of a computer system.
- Finding intensity statistics for a multiple-scatter model of wave propagation through a random medium.
- Development of algorithms for singularity-free solutions of field equations resulting from an action principle in pure field theory.
- Generating approximate solutions to boundary value problems.
- Generating approximations to e^{-x} valid on an infinite interval.
- Computing symbolic integrals and polynomial coefficients for nonlinear structural analysis.
- Developing coefficients for finite difference operators on complicated boundaries.
- Solving for current in terms of voltage in a special circuit with nonlinear element.
- Analyses of tedious and complicated circuits.
- Symbolic solution of a sparse 8 by 8 linear system.
- Development of helicopter equations requiring extensive coordinate transformations in symbolic form.
- Manipulation and solution of difficult multivariate systems of equations.
- Solution of systems of second order differential equations.

IMPROVED ANALYTICAL CAPABILITY

In addition to the extension of analytical capabilities it is also important to improve existing capabilities. These improvements manifest themselves in such benefits as time and cost savings, easier use, more easily interpreted output, etc. Finding an analytic solution to a problem can offer definite advantages over using a numerical approximation if the solution must be evaluated for many values of the parameters. MACSYMA is ideal for this type of application and offers other features such as its plotting capability that can be used advantageously.

Some of the users of the NALCON MACSYMA have reported applications that were done with MACSYMA more economically, faster, or otherwise better than would have been possible without MACSYMA. These include:

- Development of specialized graph paper using MACSYMA interactive plotting routine.
- Development of a model for exploring the behavior or various forms of functions in approximating the solutions to differential equation boundary value problems. The flexibility of input made possible by the use of MACSYMA largely contributed to the practicality of this approach.
- Generation and plotting of biharmonic functions and solutions to boundary problems involving biharmonic equations.
- Generating plots of target strength vs frequency and pinging angle of acoustic signal.
- Checking of complicated contour integral.
- Solution of an eight by eight linear system arising in an electro-magnetic boundary value problem. Considerable time was saved through the use of MACSYMA.
- Analyses of electronic circuits in much more detail than would have been practical without MACSYMA.
- Differentiation and simplification of very complicated expressions and determination of roots of high order polynomials.
- Generation of graphs and related data fitting for a technical report. Work was done more economically both in time and cost than would have been possible without the aid of MACSYMA.

- Derivation of difference equations. Work requiring several days for two senior analysts was done in an afternoon with MACSYMA.

- Algebraic simplification. Work was done more accurately with MACSYMA than would have otherwise been possible in the allotted time.

INDIRECT ADVANTAGES

In addition to benefits gained through direct applications of MACSYMA to Navy research and solution of Navy problems, there are other benefits that are more obscure and less easily assessed but nonetheless important in the overall functioning of Naval research and development carried out in the laboratories.

By design, MACSYMA is a system that appeals to the higher level scientists who develop approaches and methods but are frequently not directly involved or interested in writing computer programs to implement their work. The MACSYMA language and display are sufficiently similar to general mathematical notation and response from MACSYMA is generally so much better than hand operations that it is readily accepted and used by scientists and engineers who would otherwise not use the computer in their work.

Frequently a FORTRAN program may require many pages of instructions to perform the required computations while a MACSYMA program to perform the same computations requires less than one page. For exploratory calculations, this compactness of program is a distinct advantage.

The numerical methods used in a computer program are often dictated by the requirement that the approximations must be set up manually. Use of MACSYMA to set up the approximations allows more accurate, albiet less simple, expressions to be used. For example, in series approximations more terms of the series can be used with no visible additional effort.

Interest in MACSYMA provides a common ground for Navy scientists of diverse disciplines to discuss methods they have developed that may be helpful in fields other than their own. The desirability of such communication has long been recognized but any efforts to bring it about have been virtually fruitless.

Furthermore, since users of MACSYMA are drawn from both the academic and the applied research and development areas, the communications facilities associated with MACSYMA foster interchange of ideas between these two communities of users and accelerate what is often a slow transfer of technology.

MACSYMA is a resource which is not indigenous to any of the Navy laboratories but is equally accessible to all by means of NALCON exclusively. Moreover, it is the most advanced interactive symbolic manipulation capability available. The availability of MACSYMA tends to promote use of NALCON and familiarization with NALCON protocol within the Navy laboratories and demonstrates that a centrally provided and maintained resource can be made accessible to be shared by the entire laboratory scientific engineering community to the benefit of all.

FUTURE TRENDS

As MACSYMA becomes more widely known in the Navy Laboratories and as its interface with numeric computation facilities is further developed, its use will surely continue to increase.

At each of the laboratories there will most likely be a group of scientists and engineers who use MACSYMA, a few on a fairly regular basis and others sporadically when the course of their work demands. In both cases, the capabilities of MACSYMA should extend the frontiers of Navy research and development in areas that were formerly limited by human capacity to perform the complicated and tedious mathematical derivations necessary for more comprehensive investigation.

Although the effort during the past year in getting participation in MACSYMA throughout the Navy Laboratories was highly successful, there are still a few laboratories that are not participating. Since the MACSYMA system frequently is carrying a capacity load during peak operating hours, encouraging additional use of the system seems unwise as long as current conditions prevail. However, there are steps being taken to expand the facilities at MIT to accommodate more users. When this expansion has been completed, a concerted effort will be made to get participation in MACSYMA at all the Navy Laboratories.

The Navy has used NALCON membership in the MACSYMA consortium to provide some benefits to the scientific/engineering community of other branches of the service by honoring requests to include a few of their members in the MACSYMA course and a larger group in the NALCON MACSYMA newsletter distribution. There have been recent requests from both the Army and Air Force for participation in the NALCON MACSYMA consortium membership. This indicates that NALCON activity in MACSYMA will very likely extend beyond the Navy Laboratories.

During peak operating hours (1000 through 1500 Eastern time), the MACSYMA system frequently reaches its capacity for accommodating users. The effect on the user community is that response is slow and attempts to sign onto the system are sometimes rejected. The Laboratory for Computer Science at MIT is aware of these conditions and is in the process of expanding its facilities to accommodate more users by leasing 256K of memory from September 1978 until a one million word memory is received in January 1979. Additional disks are also expected to be added in October 1978 to double the disk capacity. Efforts to encourage more participation in MACSYMA in the Navy Laboratories have been limited as long as the crowded conditions prevail but will be stepped up as soon as the capacity of the system is expanded.

One of the major improvements that is currently under development within MACSYMA is the interfacing of MACSYMA with the set of efficient numerical computation subroutines well known as the IMSL (International Mathematical and Statistical Library) routines. The inclusion of this organized high quality set of numerical and statistical routines will constitute a substantial extension of MACSYMA capabilities.

Among the ways in which MACSYMA is currently being used in NALCON community is that of developing the algorithms and other mathematical expressions to be used in FORTRAN programs on laboratory computers such as the CDC 6000. Although it is possible to have expressions generated by MACSYMA punched on paper tape at a teletype terminal and subsequently read from the paper tape into the Navy laboratory computer, this process is, to say the least, inconvenient. The Navy laboratory computer network is in the process of developing a direct file transfer capability between computers on the network. Current schedules call for this to be available in all NALCON computers by May 1979. By use of the direct file transfer it will be possible to readily incorporate code generated with MACSYMA in to programs that will run on the NALCON computers, thereby combining the advantages of both.

In a recent paper, Brown and Hearn[24] discussed the interdependence of symbolic computation and numerical methods. Their concluding statement was "The impending marriage between these two ungainly disciplines will not be based on either love or convenience, but on the mathematical foundation that they share and the rich variety of important practical problems that neither can solve without the help of the other. In short, this is an exciting research frontier with brilliant prospects."

CONCLUSIONS AND RECOMMENDATIONS

The extension of human analytical capacity through symbolic manipulation on a computer is especially valuable to scientists and engineers in a research and development environment such as that found in the navy laboratories. Among all the symbolic manipulation systems that have been developed, MACSYMA is in many ways the most advanced, well maintained, and readily accessible to all Navy laboratories.

Since July 1977 when NALCON joined the MACSYMA consortium, the number of Navy MACSYMA users has steadily increased from nine to thirty seven. Publication of three newsletters, individual contact and assistance, and a NALCON MACSYMA course were factors in stimulating interest. Response to each of three usage surveys was almost total and brought reports of application of MACSYMA to Navy problems most of which would have been impossible, impractical, more difficult, or more costly without this resource.

The stated objective of the MACSYMA Usage Experiment for NALCON (Appendix A, p. A5) was "to determine the benefits to the Navy laboratory community of making a unique resource (MACSYMA-Project MAC's Symbolic Manipulator) available to the Navy laboratory community via NALCON." Considerable progress has been made in fullfilling this objective and the observed benefits are substantial. What has taken place is just a beginning. There is potential for much greater benefits to be realized through continuation of MACSYMA consortium membership and the broadening and refining of the use of MACSYMA in the Navy Laboratory community.

Is it recommended that NALCON membership in the MACSYMA consortium be continued and the exchange of information within the NALCON MACSYMA user community and with the general MACSYMA community be encouraged and supported as needed.

It is further recommended that efforts to combine and exploit the symbolic manipulative capability of MACSYMA and the numeric computational capability of the NALCON computers be encouraged and supported.

Since NALCON is the only MACSYMA Consortium member in the Department of Defense it is recommended that serious consideration be given to taking action to make the Navy a focal point for MACSYMA use within the Department of Defense.

ACKNOWLEDGMENT

The assistance of Dr. Elizabeth Cuthill who provided guidance and resources for this report is gratefully acknowledged.

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APPENDIX A

NALCON MACSYMA NEWSLETTER 1

Contents

Section I

Introduction

This Newsletter is intended to disseminate information about MACSYMA (Project MAC's Symbolic Manipulation System for performing symbolic as well as numerical mathematical manipulations) among members of the Navy Laboratory community.

On page 16 of this first issue is a questionnaire. The response to the questionnaire will be used to compile a distribution list for future issues of the newsletter. PLEASE RETURN THE QUESTIONNAIRE IF YOU WANT TO CONTINUE TO RECEIVE THE NEWSLETTER!

The newsletter will cover such topics as MACSYMA Capabilities, including Language, Utility and Network features, progress on the MACSYMA Experiment, MACSYMA reference materials including Conferences, Publications, usage and applications of MACSYMA in the Navy Laboratories, and exchange of information among MACSYMA users.

How it All Started

A Navy Laboratory Computer Network (NALCON) was authorized by SECNAV Instruction 5420.176 on Interlaboratory Computing dated 8 October 1974 with the following major goals:

Interconnection of all Navy laboratory major computers, ready availability of computer resources at all laboratories to all Naval laboratory scientists and engineers, establishment of centers of excellence in designated service areas for which there is wide usage or need and for which specialization would provide more effective service or reduce costs, provision of coordinated planning and orderly growth of computing power within the laboratories.

A NALCON Experiment to determine the impact of computer networking on the Navy laboratories was set up for FY 77 and FY 78 in three parts:

The General Usage Experiment
The Technical Experiment
The Management Experiment

One component of the Technical Experiment to demonstrate resource sharing is the MACSYMA Usage Experiment intended to enrich the mathematical computing resources of the laboratories. The plan for the MACSYMA Usage Experiment, which includes publication of this newsletter is reproduced in Section III.

NALCON will use ARPANET (a computer network developed by the Advanced Research Projects Agency of the Department of Defense) as a communication media. MACSYMA is a resource of ARPANET being made available via membership in a consortium. NALCON has joined this consortium. Navy Laboratory scientists will have free access to MACSYMA until May 1978 to explore its capabilities and application to Navy problems. In return, information concerning the usage, experience, and benefits derived will be solicited for this experiment report. (See Section III).

Section II

What Can MACSYMA Do for You

MACSYMA, developed under the direction of Prof. Joel Moses at MIT, has been described as an automated mathematical co-worker. It can handle both symbolic and numerical mathematics. It is an interactive system that can be accessed from a wide variety of terminals including plotting terminals, such as the Tektronix. Generally speaking, the "knowledge" built into the MACSYMA system represents the most advanced techniques and algorithms and is continually being updated by researchers and "system hackers" of the MATHLAB group in the Laboratory of Computer Science (formerly Project MAC) at MIT. MACSYMA is maintained only on the MATHLAB computers at MIT but it can be used from any terminal that has access to NALCON (or more generally ARPANET). The following is a list of the principal capabilities of MACSYMA. More detail is given in the references cited in Section IV. A few of these capabilities are demonstrated on page 4 in a reproduction of part of a terminal session with MACSYMA.

Capabilities of MACSYMA

Variable precision fixed and floating point arithmetic
Two-dimensional display of expressions
Rational function manipulation
Trigonometric function manipulation
Power series manipulation
Matrix manipulation
Integration subsystems
Factorization of polynomials
Pattern matching
Noncommutative operations
Tensor manipulation
Laplace and inverse Laplace transforms
Special functions
Plotting
Series summation
Definition of functions
String and list processing
FORTRAN output
Interactive capabilities
Continuing system maintenance

(C9) D2;

(D9) $$\frac{2\ X}{X^{3} + 1}$$

(C10) INTEGRATE(%,X);

SIN FASL DSK MACSYM being loaded
loading done

SCHATC FASL DSK MACSYM being loaded
loading done

(D10) $$2\ \left(\frac{\mathrm{LOG}(X^{2} - X + 1)}{6} + \frac{\mathrm{ATAN}\left(\frac{2\ X - 1}{\mathrm{SQRT}(3)}\right)}{\mathrm{SQRT}(3)} - \frac{\mathrm{LOG}(X + 1)}{3}\right)$$

(C11) DIFF(%,X);

(D11) $$2\ \left(\frac{2}{3\ \left(\frac{(2\ X - 1)^{2}}{3} + 1\right)} + \frac{2\ X - 1}{6\ (X^{2} - X + 1)} - \frac{1}{3\ (X + 1)}\right)$$

(C12) RATSIMP(%);

(D12) $$\frac{2\ X}{X^{3} + 1}$$

(C13) TAYLOR(SQRT(1+X),X,0,5);

HAYAT FASL DSK MACSYM being loaded
loading done

(D13)/T/ $$1 + \frac{X}{2} - \frac{X^{2}}{8} + \frac{X^{3}}{16} - \frac{5\ X^{4}}{128} + \frac{7\ X^{5}}{256} + \ldots$$

A4

Section III

The MACSYMA Usage Experiment for NALCON

1. Objective: To determine the benefits to the Navy Laboratory Community of making a unique resource (MACSYMA - Project MAC's Symbolic Manipulator) available to the Navy Laboratory Community via NALCON.

2. Procedure:

a. Identify individuals with applications for MACSYMA at the Navy Laboratories and provide them with documentation on the MACSYMA system along with instructions for accessing it.

b. Make MACSYMA courses available to interested Navy Laboratory personnel.

c. Identify and document Navy applications of MACSYMA.

d. Prepare and publish a Newsletter for potential and actual Navy MACSYMA users.

e. Collect data from MACSYMA accounting files and directly from Navy MACSYMA Users and prepare a report assessing the benefits of MACSYMA to the Navy Laboratory community. The data to be collected includes:

- A history of MACSYMA usage by Navy Laboratories
- Applications of MACSYMA by Navy Laboratories
- The impact of the availability of MACSYMA on these applications - in particular -

  (1) Calculations performed and problems solved that would have been impossible or impracticable without MACSYMA.
  (2) Calculations performed and problems solved that were done better (more economically, more completely, more expeditiously) with MACSYMA
  (3) Calculations performed and problems solved for which MACSYMA offered no significant advantage.

The final report on the experiment will also include information on problems in the usage of MACSYMA and suggestions for improvement of MACSYMA for Navy applications along with the estimated impact of the implementation of those suggestions on the Navy Laboratory Community.

Section IV

MACSYMA Users Conference Proceedings Now Available:

The First MACSYMA Users Conference was held at the University of California at Berkeley, July 27-29, 1977 with 89 attendees. Richard Fateman of the University of California at Berkeley was General Chairman and Carl Andersen of the College of William and Mary in Virginia was Program Chairman. The conference proceedings containing the papers presented at the conference has been published as a NASA Report:

"Proceedings of the 1977 MACSYMA Users Conference," NASA CP-2012 1977.

and is available for $12.50 from National Technical Information Services Springfield, Virginia 22161.

The table of contents of that report is reproduced here to give an idea of the scope of work presented. Included were papers on algorithms and techniques for doing symbolic mathematics on a computer, on various MACSYMA capabilities, on user aids for MACSYMA, on applications of MACSYMA, and on some exciting work in computing closed forms for sums. Two of these papers, numbers 10 and 14, were by Navy authors. Their summaries are included in Section IV.

Contents

Section V

MACSYMA References and Information:

An excellent discussion of the philosophy, goals and early achievements of the MACSYMA system is given in the following reference.

Martin, W.A. and Fateman, R.J., "The MACSYMA System", Proceedings of the Second Symposium on Symbolic Algebraic Manipulation, S.R. Petrick, editor, Association for Computing Machinery, March 1971, pp 59-75.

These Proceedings were copyrighted in 1971 by the ACM Special Interest Group on Symbolic and Algebraic Manipulation and were obtainable for $15.00 per copy from Association for Computing Machinery, 1133 Avenue of the Americas, New York, New York 10036.

Another reference that gives an overview of MACSYMA capabilities and some of its applications is

L.K. Meals, "MACSYMA - A Resource for the Navy Laboratory Computer Network", David W. Taylor Naval Ship Research and Development Center, Computation, Mathematics, and Logistics Department, Departmental Report CMLD-77-04 (January 1977).

A limited number of copies are available from the author, Code 1826, David W. Taylor Naval Research and Development Center, Bethesda, MD. 20084.

A "must" for anyone who wants to use MACSYMA are the three following references.

MATHLAB Group, "MACSYMA Reference Manual, Version Eight," Massachusetts Institute of Technology, Cambridge, Mass. (Nov. 1975) or version nine (July 1977).

Lewis, E., "An Introduction to ITS for the MACSYMA User," The MATHLAB Group, Massachusetts Institute of Technology, Cambridge, Mass., (July 25, 1977).

MATHLAB Group, "MACSYMA Primer", Massachusetts Institute of Technology, Cambridge, Mass., (July 21, 1977).

These can be obtained by contacting Dr. E. Cuthill, Code 1805, or K. Meals, Code 1826, David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland 20084.

Another very useful document for new users of MACSYMA is entitled "MACSYMA Notes". It is a guideline one can follow at a terminal to access MACSYMA and to explore MACSYMA capabilities described and demonstrated in MACSYMA files. This document can also be obtained from Dr. Cuthill, Code 1805, DTNSRDC or K. Meals, Code 1826, DTNSRDC.

Section VI

In the Navy Labs:

MACSYMA is available now via ARPANET to any member of a Navy Laboratory who wants to try it. For information on how to get access to MACSYMA contact your laboratory's NALCON representative. A list of the Laboratories and their respective NALCON representatives and current users follows. If we have missed any Navy Users, please let us know.

DTNSRDC	MACSYMA Users
Frank Brignoli David W. Taylor Naval Ship Research and Development Center Code 1826 Bethesda, Maryland 20084 AVON: 287-1618--(202)227-1618	E. Cuthill M. Haas M. Hurwitz K. Meals F. Theilheimer
NCSL Dave Brown Naval Coastal Systems Lab Code 731E Panama City, Florida 32401 AVON: 436-4112 or 436-4132 (904)234-4112(4132)	P. Bishop D. Brown
NRL Anita Skelton Naval Research Lab Code 4223.12 4555 Overlook Ave., S.W. Washington, D.C. 20375 (202)767-3190	W. Ament R. Krutar

NUSC
John McGilvary
Naval Underwater Systems Center
Code PA-41
Fort Trumbull
New London, Conn. 06320
AVON: 636-2991--(203)442-0771

NSWC/WOL
Robert D. Archer
Naval Surface Weapons Center
Code 332
White Oak
Silver Spring, Maryland 20910
(202) 394-1909 or 1745

NSWC/DL
E.P. Stemple
Naval Surface Weapons Center
Code KOE
Dahlgren Lab
Dahlgren, Virginia 22448
AVON: 249-8178--(703)663-8178

NWC
John Zenor
Code 4030
Naval Weapons Center
China Lake, California 93555
AVON: 245-3817,3888--(714)939-3888

NOSC
Bob Unger
Code 4535
Naval Ocean Systems Center
San Diego, California 92132
AVON: 933-2721--(714)225-2721

J.G. Noel
Code 5200
Naval Ocean Systems Center
San Diego, California 92132
AVON: 933-6011--(714)225-6011

NADC
Ted Calkins
Code 8522
Naval Air Development Center
Warminster, Pennsylvania 18974
AVON: 441-2424/98/19--(215)672-9000x2424/98/19

Three papers on MACSYMA Applications were given by Navy Laboratory personnel and have appeared or will appear in conference proceedings. The first two, by Ament and by Cuthill, were given at the First MACSYMA Users Conference at the University of California in Berkeley in July and appeared in the Proceedings mentioned in Section IV. The third paper, by Cuthill and Meals, was presented at the 23rd Conference of Army Mathematicians held at NASA Langley Research Center in April 1977. It will appear in the Proceedings of that Conference. Summaries of these three papers follow.

PURE FIELD THORIES AND MACSYMA ALGORITHMS - William S. Ament

A pure field theory attempts to describe physical phenomena through singularity-free solutions of field equations resulting from an action principle. The physics goes into forming the action principle and interpreting specific results. Algorithms for the intervening mathematical steps are sketched. Vacuum general relativity is a pure field theory, serving as model and providing checks for generalizations. The fields of general relativity are the 10 components of a symmetric Riemannian metric tensor g_{ij}. Algebraic properties of g_{ij} are exploited in top-level MACSYMA commands toward performing some of the algorithms of that generalization. The light-cone for the theory as left by Einstein and Straus is found and simplifications of that theory are discussed. Attention is called to the need for spinor theories; the algebra of g_{ij} may help in their construction.

RATIONAL APPROXIMATION TO e^{-x} WITH NEGATIVE REAL POLES
-- Elizabeth Cuthill

This note describes an application of MACSYMA to the generation of an expansion in terms of Laguerre polynomials to obtain approximations to e^{-x} on $(0,\infty)$ of the form

$$\frac{P_m}{\left(1 + \frac{x}{m}\right)^m}$$

Here P_m is a polynomial of degree m-1 in x. These approximations are compared with those developed by Saff, Shonhage, and Varga [1]. Theirs are optimum Chebyshev approximations. In particular, a comparison of the maximum errors in the Chebyshev sense showing the superior performance of the approximations in [1] when this norm is used, while the approximations developed in this paper are superior when mean square errors are compared.

Kaufman and Taylor [2] consider approximations to e^{-x} of the form

$$\frac{P_m}{(1+B_1x)\ (1+B_2x)\ldots(1+B_mx)}$$

where $B_1,\ldots,B_m$ are positive real numbers. In this note we also consider the expansion of $e^{-x}(1+B_1x)\ldots 1+B_mx)$ in terms of Laguerre polynomials. The first few terms of such an expansion are derived with MACSYMA.

1. Saff, E.B.; Schonhage, A.; and Varga, R.S.: Geometric Convergence to e^{-x} by Rational Functions with Real Poles. Numer. Math. 25, 1976, pp. 307-322.
2. Kaufman, E.H., Jr.; and Taylor, G.D.: Best Rational Approximations with Negative Poles to e^{-x} on $[0,\infty)$. To appear in Pade and Rational Approximations: Theory and Applications (E.B. Saff and R.S. Varga, Eds), Academic Press, Inc.

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APPLICATION OF MACSYMA IN THE SOLUTION OF BOUNDARY VALUE PROBLEMS

Dr. Elizabeth Cuthill and L. Kenton Meals

ABSTRACT. MACSYMA (Project MAC SYmbolic MAnipulation System) is used to develop a number of solutions for a sample linear boundary value problem, and results are compared.

A brief outline of MACSYMA capabilities is given, followed by a general description of the class of problems treated, and the specific boundary value problem of this class used to exemplify the application of MACSYMA.

A brief overview of the approach to solution with MACSYMA and a MACSYMA demonstration of this approach for one approximate solution of the sample problem is given.

Ten approximations to the solution of the boundary value problem obtained using MACSYMA, are compared with the true solution by means of MACSYMA-generated error curves.

QUESTIONNAIRE

Keep my name on the distribution list for NALCON MACSYMA Newsletter

________________________________(signed)

Add the following names to the distribution list for NALCON MACSYMA Newsletter.

________________________________Name

________________________________Address

____

________________________________Name

________________________________Address

____

I would be interested in attending a 2 or 3 day course on MACSYMA

______Yes ______No

Suggested items for future issues of NALCON MACSYMA Newsletter

Please return to: L. K. Meals
Code 1826
David W. Taylor Naval Ship R&D Center
Bethesda, MD 20084

APPENDIX B

NALCON MACSYMA NEWSLETTER 2

Contents

SECTION I

Introduction

This Newsletter is intended to disseminate information about MACSYMA (Project MAC's Symbolic Manipulation System for performing symbolic as well as numerical mathematical manipulations) among members of the Navy Laboratory community.

It will cover such topics as MACSYMA Capabilities, including Language, Utility and Network features, progress on the MACSYMA Experiment, MACSYMA reference materials including Conferences, Publications, usage and applications of MACSYMA in the Navy Laboratories, and exchange of information among MACSYMA users.

Readers are invited to submit material along these lines for publications.

SECTION II

The MACSYMA Course

A three-day course in MACSYMA was held at DTNSRDC on February 6 thru February 8, 1978. Despite the blizzard that struck the east coast on February 6, there were thirty-five (35) attendees at the course. The following installations were represented: Naval Research Laboratory, Naval Coastal Systems Laboratory, Naval Underwater Systems Center, David W. Taylor Naval Ship R&D Center, U.S. Army Watervliet Arsenal, National Bureau of Standards, Johns Hopkins Applied Physics Laboratory, and Operations Research Inc., a Navy contractor.

The instructors, Michael Genesereth and Jeffery Golden of the Math lab Group in the Laboratory for Computer Science at MIT presented in the three-day period essentially the same course they have given to students at MIT over a period of several weeks. Problems were distributed and eight terminals were reserved for class use during the three-hour break between morning and afternoon sessions. MIT provided a special login name and password for access to MACSYMA by participants in the course. A total of 49 hours and 34 minutes of connect time and 16 minutes and 7 seconds of run time were used by the class.

On the final day, four of the experienced MACSYMA users described problems in which they had applied MACSYMA.

George Humfeld presented an application to battery life study where he used the plotting capability to generate graph paper on which the functions of interest would plot into straight lines for easy extrapolation. He also distributed instructions for using his plotting programs. Myles Hurwitz described a structural analysis application which involved solving an overdetermined system of linear equations by an orthonormalization technique set up as a MACSYMA block function.

Dr. Theilheimer described the development of cubic splines using the versatility of MACSYMA function definition to satisfy the conditions for knots in the spline. Dr. Ament described an approach he is taking with MACSYMA on a problem involving reflection and refraction of electromagnetic waves through ocean surface waves.

In the final session some of the mysteries of unexpected responses from MACSYMA were revealed and a bit of insight was given into some of the design and development of the MACSYMA System.

Page 4 is a copy of the final agenda for the course. A list of materials that were supplied to attendees is included under MACSYMA References in Section VI.

The special login name and password used in the course will be discontinued. Persons signing onto MACSYMA using this special login name will receive the following message:

> NAVY will be phased out as a signon ID by March 5. If you wish to continue using MACSYMA please contact:
>
> E. Cuthill at telephone 202-2271645 or by message to ELIZC
>
> or K. Meals at telephone 202-2271622 or by message to KM

to get your own ID.

MACSYMA Course

February 6-8, 1978

DAVID W. TAYLOR NAVAL SHIP R&D CENTER
Bethesda, MD 20084

Building 191 - Conference Room

INSTRUCTORS -- Michael R. Genesereth; Jeffery P. Golden
(Laboratory for Computer Science,
Massachusetts Institute of Technology)

SCHEDULED SESSIONS

6 Feb	0900-1100	Introduction to MACSYMA and the system Automatic and non-automatic simplification of expressions
	1100-1400	Lunch / Terminal Signup Sessions
	1400-1600	MACSYMA as a programming language Multiple internal representations and the consequences
7 Feb	0900-1100	Mechanism for evaluation and simplification User aids, maxims for MACSYMA usage, and secondary storage
	1100-1400	Lunch / Terminal Signup Sessions
	1400-1600	Plotting with MACSYMA The editors TECO and EMACS
8 Feb	0900-1100	Discussion of special problems

SPEAKERS:

W. Ament	NRL
G. Humfeld	DTNSRDC
M. Hurwitz	DTNSRDC
F. Theilheimer	DTNSRDC

8 Feb	1100-1400	Lunch / Terminal Signup Sessions
	1400-1600	Highlights from consultation sessions

ADDITIONAL INFORMATION

.... There will be 8 terminals reserved for class use from 1100-1400 daily. Signup sheets will be provided. Locations and terminal types are:

	Bldg	Room	Terminal Type		Bldg	Room	Terminal Type
1.	191	Conf.	T.I. Silent	5.	17	104	GE Terminet
2.	191	131	T.I. Silent	6.	17	104	GE Terminet
3.	191	131	Dataphone 4800	7.	17	202	Spintronic
4.	192	104	TEKTRONIX 4015-1	8.	17	202	TEKTRONIX 4015

.... CAFETERIA LUNCH HOURS ARE: 1100 - 1300

SECTION III

Summary of NALCON MACSYMA Usage Oct.-Nov. 1977

The introductory free use of MACSYMA as a resource of the Navy Laboratory Computer Network is part of the MACSYMA Usage Experiment for NALCON described in Section III of the first NALCON MACSYMA Newsletter (21 Oct 1977). One of the requirements of this experiment is a report assessing the benefits of MACSYMA to the Navy Laboratory community. The first bi-monthly questionnaire was sent on 6 Dec 1977 to each of the ten users who had an ID on the NAVY users file in MACSYMA and had used the system between 1 Aug and 30 Nov 1977. Total time from the MIT MACSYMA accounting file was supplied to each user along with the questionnaire. A summary of questions and responses follows.

MACSYMA USAGE RESPONSE FORM

- NAME: All Navy Users (10)
- ID:
- USAGE PERIOD: 1 October - 30 November 1977
(1 user 1 August - 30 November)
- CONNECT TIME: 35 Days 20 Hours 4 Minutes
(860.067 Hours)
- RUN TIME: 18 Hours 41 Minutes 46 Seconds
- Are the above times approximately correct? Yes
- Indicate percentage of time for each:

13.4	Training
4.1	Demonstration
68.6	Research and Development of Techniques
13.6	Direct Navy Application
	(Insert your own categories if none of the above apply)
.3	Other

B5

- Briefly describe each of the applications, research, and/or technique developments. Indicate, if possible, the additional MACSYMA connect and run time which may be required for each.

1. Solved symbolically sets of balance equations from a queueing-network representation of a computer system.

2. Developed specialized graph paper using MACSYMA plotting capability and also generated illustrations for a report.

3. Used MACSYMA in study toward finding intensity statistics for a multiple-scatter model of wave propagation through a random medium.

4. Developed a least-square orthonormalization program and procedures for its use.

5. Checked a technique for locating sensors on a structural model.

6. Generated approximate solutions to differential equations - boundary value problems using various methods including Galerkin, least squares, etc.

7. Generated higher order difference equations.

8. Generated approximations to e^{-k} valid on an infinite interval.

9. Generated and plotted biharmonic functions and solutions of BV problems involving biharmonic equations.

10. Calculated target strength reduction due to compliant coatings on plates.

11. Checked a complicated contour integral.

12. Solved an 8 x 8 linear system arising in EM boundary value problem with considerable saving of time.

13. Computed symbolic integrals and polynomial coefficients for NASTRAN non-linear project.

14. Solved analytically a plane stress problem for a plate with holes and reinforcements.

15. Solved a number of trial problems connected with B-spline representation of curves and surfaces.

16. Used MACSYMA to perform tedious algebra used in CDC 6000 programs for interactive graphics and fluid mechanics.

17. Developed software for the PDP-11 and simulated its use.

- Are you considering any additional MACSYMA applications?

  8 positive responses with the following comments

1. Algebra for second-order scaling in a classified problem.

2. Algebra for EM waves in magneto plasmas.

3. Algebra and series expansions for some EM wave propagation problems.

4. Simple modelling of a towed vehicle stability augmentation control system.

5. Some problems in propeller design.

6. "I would hope that MACSYMA would always be available as a tool."

- Did you, or do you expect to publish or report any work in which MACSYMA was used? If so, please furnish identifying information.

1. The three papers whose abstracts appeared in Section VI of the first NALCON Newsletter (21 Oct 1977).

2. MACSYMA use in developing specialized graph paper and graphs using MACSYMA will appear as an appendix in a report to the sponsor of a study.

3. A TM is being written on target strength reduction due to compliant coatings on plates where MACSYMA was used for the calculation.

4. "New Large Deflection Analysis for NASTRAN" by Myles M. Hurwitz, was presented at the 6th NASTRAN Users' Colloquium held at Lewis Research Center, Cleveland, Ohio, Oct 4-6 1977.

5. "Intensity Statistics for a Multiple-Scatter Model Via Computer Symbol Manipulation" by W.S. Ament published in Effect of the Ionosphere on Space Systems and Communications, John M. Goodman, Ed. Naval Research Laboratory document based on Ionosphere Effects Symposium held in Crystal City, Arlington, Va. Jan. 20-22, 1975.

. Have you done work that would have been impossible or impractical without MACSYMA? If so, describe briefly.

1. Symbolic solution of sets of balance equations from a queuing-network representation of a computer system.

2. Finding intensity statistics for a multiple-scatter model of wave propagation through a random medium.

3. Developing algorithms for singularity-free solutions of field equations resulting from an action principle in pure field theory.

4. Generating approximate solutions to boundary value problems.

5. Generating approximations to e^{-x} valid on an infinite interval.

6. Computing symbolic integrals and polynomial coefficients for NASTRAN nonlinear project. Expressions are extremely complex and virtually impossible to solve by hand.

7. Developing coefficients for finite difference operators on boundaries that would be too complicated to do easily and error free by hand.

- Have you done work that was done better (more economically, completely, expeditiously) with MACSYMA? If so, describe briefly.

1. The interactive graphics of MACSYMA allowed real time development of specialized graph paper making the effect of adding and dropping lines immediately apparent.

2. Ability to set up and change defining expressions for input to approximation programs made much more generality of application possible in generating solutions to differential equation boundary value problems.

3. Generated and plotted biharmonic functions and solutions to boundary value problems involving biharmonic equations.

4. Generated plots of target strength NS frequency and pinging angle.

5. Checked complicated contour integral.

6. Considerable time was saved in solving an 8 x 8 linear system arising in EM Boundary Value problem.

7. Avoided Gaussian quadrature by computing symbolic integrals with MACSYMA for NASTRAN non-linear project. Time required for this portion of analysis was reduced by a factor of 4.

- Has MACSYMA offered any other significant advantages in the performance of your work? If so, describe briefly.

1. Offers quick and accurate way to perform or check matrix manipulations, differentiations, integrations and algebraic operations.

2. More flexible than FORTRAN.

3. Matrix handling.

4. The ability to do algebra quickly and accurately allows higher order approximations to be built into numerical computations.

- List any suggestions you have for improvement of MACSYMA.

1. More work space.

2. .Make GRIND give syntax as exactly as possible.

3. Incorporate more features of APL.

4. Comments on clarification of system messages, documentation and reliability most of which were resolved in the MACSYMA course and the new MACSYMA Manual.

- What features of MACSYMA do you find of most value to you?

1. Interactive mode and direct help from MIT personnel.

2. Plotting.

3. Matrix handling.

4. Algebraic manipulation and simplification including rational function manipulation and simplification.

5. Symbolic differentiation, integration, substitution.

6. Generality of mathematical operations and wealth of available commands.

- What other symbolic manipulation systems have you used? How does MACSYMA compare with them?

Only 3 had used any other system. Two had tried IAM, two had used FORMAC, and one had used REDUCE. All agreed that MACSYMA has far more capabilities than any other system they have used.

- List any suggestions for improving this questionnaire and/or for helping the user community.

1. Include address where responses to questionnaire should be sent.

2. More clarity and compactness in manuals.

3. Prepare a simple user-oriented handbook similar to the NLS quick reference or NCSC B5500 user guide.

4. MACSYMA course.

5. Better dissemination of vital information to users.

SECTION IV

MACSYMA Applications in the Navy Labs

A. "Intensity Statistics for Multiple-Scatter Model Via Computer Symbol Manipulation" by W.S Ament, Code 5404 NRL, Effect of the Ionosphere on Space Systems and Communications John M. Goodman, ed. NRL 1975.

In propagating through a random medium, an initially coherent wave becomes increasingly random with distance D from its source. But the field can get no more than totally random, i.e., Rayleigh-distributed. Here the mean-square intensity I_2 becomes twice the square of the mean intensity I_1. Theories of multiple scattering should predict I_2 for large enough D that the Rayleigh result is visibly approached.

The simplest non-trivial problem of this class has a plane, two dimensional, coherent wave incident at D = 0 on a halfspace containing phase shifting screens. The phase-shifts are correlated in transverse u,v-directions but not along the D axis. The process is described by a function F(u,v,D) satisfying[1,2]

$$F_D = 2i\, F_{uv} - HF\{2 + C(u+v) + C(u-v) - 2C(u) - 2C(v)\} \qquad (1)$$

Here H is mean-square phase shift in a ray parallel to the D-axis; C(u), with C(0) = 1, is this phase shift's normalized correlation in the transverse u direction. Thus the amplitude of the coherent wave falls off in D > 0 as exp(-HD/2) while on the present 'parabolic' assumptions of forward scatter only, the total intensity I_1 remains constant at all depths D. Function F(u,v,D) describes the intensity statistics, with $I_2(D)$ = F(0,0,D), and with F(u,0,D)/F(0,0,D) the normalized single-frequency intensity correlation function for transverse antenna separation u.

We report some considerations and a few preliminary results of computer symbol manipulations toward finding the intensity statistics, particularly aimed at the behavior of F(0,0,D) for large D. Reported calculations were done with the MACSYMA symbol-manipulating program, reached at M.I.T. via teletype.

B. Circuit Analysis

Seven circuits have been analyzed using MACSYMA. The three described below are representative samples. Work was performed by John G. Richer, Code 3134, Naval Weapons Center and was used by him in a presentation at NWC during the week of Feb. 6.

1. GENERAL AMPLIFIER ANALYSIS USING ACCURATE MODEL FOR TRANSISTOR.
The curves from which the transistor characteristics were obtained were generated using MACSYMA. They are interesting because they are in the relatively low current region characterized by high collector resistance and low beta. This circuit, for variety, does not use the popular "current source" model for a transistor, but uses the "emf source" model. In a vacuum tube, the amplification factor (u), is the ratio of change in plate-cathode emf to the change in grid-cathode emf for a constant plate current. In a transistor, the amplification factor (u_t) is the ratio of change in collector-emitter emf to the change in base CURRENT for a constant collector current (thus the fact that a transistor is a current operated device is not lost). In the region over which the curves were obtained, beta was near 100 and collector resistance was 100,000 ohms. The u_t is the product of these 2 quantities, or 10^7 volts (coll-emit) per amp (base).

2. WIEN BRIDGE PLUS OSCILLATOR (Wien bridge oscillator) The Wien bridge is analyzed and it is shown that at "resonance" ie; omega equal to 1/RC, the bridge has a gain of 1/3. The expression for gain of an oscillator was obtained by inserting an emf source (ES) into the "inverting" line. The Wien bridge feeds the "non-inverting" line. In the expression for gain it is noted that if one sets the RC equal to the X_c and the op amp gain (u) to essentially infinity, that the denominator becomes zero when RA equals twice RB (which yields a gain of 3 for the non-inverting signal from the Wien bridge) giving a loop gain of one for the Wien bridge-op amplifier combination.

3. DOUBLE TUNED TRANSFORMER This one is interesting because it demonstrates the well known double peaked response of the overcoupled double tuned transformer purely by network theory. The solution would be impracticably long and ardous by hand. It could be carried out by hand only if the performer were error free. The solution (in algebraic form) and the additional work to obtain a plot testifies to this.

SECTION V

NALCON MACSYMA USERS

ID	Name	Address
AMENT	Dr. William Ament	NRL, Code 5404
BJ	Ralph B. Johnson	DTNSRDC, Code 187
CAHM	Dr. George Humfeld	DTNSRDC, Code 187
CARTF1	Dr. Forrest L. Carter	NRL, Code 6132
CHWA	William R. McCreight	DTNSRDC, Code 1568
CMH	Dr. Cha-Mei Hui	Johns Hopkins APL, Laurel, Md.
CMLEE	Dr. Choung M. Lee	DTNSRDC, Code 1561
DBNCSL	David Brown	NCSL, Code 731E
DRINK	R. Drew Drinkard	NUSC, Code 4424
EISLER	Dr. Thomas Eisler	DTNSRDC, Code 19
ELIZC	Dr. Elizabeth Cuthill	DTNSRDC, Code 1805
FTHEIL	Dr. Feodor Theilheimer	DTNSRDC, Code 1802
HARR	William Harr	NRL, Code 7930
JFJM	John F. MacDonald	NCSL, Code 753
KM	L. Kenton Meals	DTNSRDC, Code 1826
KRUTAR	Dr. Rudolph A. Krutar	NRL, Code 5403
LOPER	Warren E. Loper	NOSC, Code 822
MEL	Mel Haas	DTNSRDC, Code 1843
MIKWYN	Dr. W. Michael Wynn	NCSL, Code 792
MYLES	Myles Hurwitz	DTNSRDC, Code 1844
NUSCNP	Ronald P. Kasik	NUSC, Code 4451
PCB	Paul C. Bishop	NCSL, Code 731E
POWELL	Gerald E. Powell	NWC, Code 3621
RICHER	John G. Richer	NWC, Code 3134
RVE	Richard Van Eseltine	DTNSRDC, Code 1843
WWJ	Dr. Walter Jones	NRL, Code 6750

SECTION VI

MACSYMA References

A. MACSYMA Course Material available upon request

1. Final course schedule
2. List of attendees
3. MACSYMA Reference Manual (Dec 1977)
4. MACSYMA Primer (Oct. 12, 1977)
5. An Introduction to ITS for the MACSYMA User (Jan. 9, 1978)
6. Set of instructors' viewgraphs
7. Set of problems
8. A subset of MACSYMA Commands, Switches, and Variables
9. Reprint: "Algebraic Simplification: A Guide for the Perplexed" by Joel Moses
10. NALCON MACSYMA Newsletter (21 Oct 1977)

B. Other MACSYMA Reference Material

1. "MACSYMA - A Resource for the Navy Laboratory Computer Network" by L. Kenton Meals, DTNSRDC Department Report CMLD-77-04 of January 1977.

2. "Proceedings of the 1977 MACSYMA Users' Conference" NASA Conference Publication NASA CP-2012. Available from National Technical Information Service (NTIS), Springfield, VA 22161, Price $12.50.

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APPENDIX C

NALCON MACSYMA NEWSLETTER 3

Contents

SECTION I

Introduction

This Newsletter is intended to disseminate information about MACSYMA (Project Mac's Symbolic Manipulation System for performing symbolic as well as numerical mathematical manipulations) among members of the Navy Laboratory community.

It will cover such topics as MACSYMA Capabilities, including Language, Utility and Network features, progress on the MACSYMA experiment, MACSYMA reference materials including Conferences, Publications, usage and applications of MACSYMA in the Navy Laboratories, and exchange of information among MACSYMA users.

Readers are invited to submit material along these lines for publication.

Outlook:

The contract is being processed to continue membership in the MACSYMA Consortium for the Navy Laboratory community.

It will be necessary to set up a mechanism through which participatng Navy Laboratories will contribute to the cost of continued MACSYMA Concortium membership during FY 79. More information will be published as it becomes available.

General interest in the MACSYMA system continues to grow as the system continues to expand and improve

SECTION III

Summary of NALCON MACSYMA Usage Dec. 1977 - Jan. 1978

The introductory use of MACSYMA as a resource of the Navy Laboratory Computer Network is part of the MACSYMA Usage Experiment for NALCON described in Section III of the first NALCON MACSYMA Newsletter (21 Oct 1977). One of the requirements of this experiment is the report assessing the benefits of MACSYMA to the Navy Laboratory community. The second bi-monthly questionnaire was sent on 14 Feb 1978 to each of the users who had an ID on the Navy users file in MACSYMA and had used the system between 1 Dec 1977 and 31 Jan 1978. Total time from the MIT MACSYMA accounting file was supplied to each user along with the questionnaire. A summary of questions and responses follows. Ongoing work already reported in Newsletter 2 is not necessarily included here.

MACSYMA USAGE RESPONSE FORM

- NAME: All Navy Users
- ID:
- USAGE PERIOD: 1 Dec 1977 - 31 Jan 1978
- CONNECT TIME: 25 days 10 hours (610 hours)
- RUN TIME: 7 hours 19 minutes

- Are the above times approximately correct? Yes

- Indicate percentage of time for each:

14.2 Training

15.2 Demonstration

42.8 Research and Development of Techniques

27.8 Direct Navy Application

(Insert your own categories if none of the above apply)

______ Other

C3

- Briefly describe each of the applications, research, and/or technique developments. Indicate, if possible, the additional MACSYMA connect and run time which may be required for each.

1. Study of scattering by corrugated dielectric surfaces.

2. Least squares processor for gated satellite altimeter echoes.

3. Manipulation of several ordinary differential equations to be used in a large numerical model of two dimensional reactive flow.

4. Differentiation and simplification of very complicated expressions and finding roots of high order polynominals.

5. Development of graphical displays for a report and special graph paper. Plotted points and tested for straight line fit.

6. Generation of biharmonic functions and plotting thereof. Solution of problems involving biharmonic equations.

7. Generation of difference equations for operator compact implicit methods for parabolic equations.

8. Application of B-spline technique to representation of certain curves and surfaces.

9. Calculation of ASEM applied loads from a set of measured strains.

10. Solution of circuits (gains, input and output impedances, graphs of gain vs frequency). This involves solving systems of equations and in a few cases evaluation and graphing of exponential equations.

- Are you considering any additional MACSYMA applications?

1. Additional analyses of circuits too complicated to be analyzed by hand.

2. Currently, working on a search problem.

3. Continuing with further applications of B-spline techniques.

- Did you, or do you expect to publish or report any work in which MACSYMA was used? If so, please furnish identifying information.

  1. Have made available a library of solved circuits and have written three in-house memos describing favorable experiences with MACSYMA.

  2. Formula manipulation for a two-dimensional reactive flow hydrocode to study ignition and flame spread.

  3. A talk entitled "The Role Of Splines in Computer-Aided Design" at SIGNUM meeting 4/19/78.

- Have you done work that would have been impossible or impracticable without MACSYMA? If so, describe briefly.

  1. Solving current vs voltage in a special circuit with non-linear element.

  2. Have solved circuits which would have required over a month (160 working hours) of error free calculations by hand.

  3. Solution of sparse 8 x 8 linear system.

- Have you done work that was done better (more economically, completely, expeditiously) with MACSYMA? If so, describe briefly.

  1. Circuit analyses were carried out more completely than would have been practical by hand.

  2. Very complicated expressions were differentiated and simplified. Roots of high order polynominals were found.

  3. Graphs for a report and special graph paper and related data fitting were done more cheaply (time and money) than would have otherwise been possible.

  4. Difference equations that took two senior analysts several days to derive were derived in an afternoon using MACSYMA.

  5. Algebraic simplification was definitely done more accurately with MACSYMA.

- Has MACSYMA offered you any other significant advantages in the performance of your work? If so, describe briefly.

  1. Permitted solution of circuits which would have been impractical to solve by hand. It also helped to establish confidence in the solutions by the scientists who proposed the circuits for analysis. It allowed checking of solutions that would have been otherwise impractical.

  2. Time savings.

- What features of MACSYMA do you find of most value to you?

  Interactive

  Generality

  Help of MIT experts

  Flexibility

  Freedom from the formality of using special language.

  Graphing capabilities

  Evaluating and simplifying complicated expression

  Algebraic and matrix manipulation

  On line reference manual feature

  Reliability of manipulations

- List any suggestions you have for improvement of MACSYMA.

  1. Make GRIND give exact syntax, i.e. tabbed so that items of same syntactical weight are listed in columns, clearly tabbed.

  2. Make it less prone to die of a syntax error.

  3. Make definition of gradient and differential operators easier.

  4. User manual.

5. More work space.

6. Better numeric (non-symbolic) operation.

7. APL-type matrix capabilities.

8. Segment function entry and manipulation.

9. Generalized function manipulation.

10. Special function, especially Bessel functions.

SECTION IV

MACSYMA Applications in the Navy Labs.

1. NALCON MACSYMA Newsletter 2, page 8 cited the following publication: "New Large Deflection Analysis for NASTRAN" by Myles Hurwitz, presented at the 6th NASTRAN Users Colloguium, Lewis Research Center Cleveland, Ohio, Oct 4-6, 1977. MACSYMA was used in this work to perform integration symbolically rather than numerically thereby realizing considerable savings in time required. Since no abstract was previously published in the Newsletter, a summary is included here. The complete paper appears in NASA Conference Publication 2018.

> A new large deflection analysis is being developed for NASTRAN Level 16 as an alterntive to Rigid Format 4, Static Analysis with Differential Stiffness, since it has been shown that differential stiffness effects alone are not sufficient to accurately solve geometrically nonlinear problems, especially those problems which involve a high degree of nonlinearity.
>
> This paper, which represents a progress report for a long term general nonlinear analysis NASTRAN project, contains (1) the theory of the structural analysis and numerical analysis methods presently used, and (2) some simple test problems comparing the new analysis with Rigid Format 4.

2. On 13 April 1978, E. Cuthill (ELIZC, DTNSRDC), participated in a seminar at Salisbury State College, Salisbury Maryland, on "Computers and Symbolic Processes". Her discussion of MACSYMA and its capabilities was very well received. At the end of the discussion, an overhead TV was used to show some actual interactions with MACSYMA. The audience posed several problems for which MACSYMA produced correct solutions creating considerable excitement!

3. On 19 April 1978, Dr. Feodor Theilheimer (FTHEIL, DTNSRDC) spoke at a meeting of SIGNUM (ACM Special Interest Group in Numerical Analysis). The talk entitled "The Role of Splines in Computer-Aided Design", described work he has performed using MACSYMA. The abstract follows:

> In computer-aided design we often express curves by means of splines, which are functions with discontinuities of some derivatives at a selected number of points, the so-called knots. We deal here pri-

marily with cubic splines where the functions between successive knots are polynomials of degree not higher than three. Interesting properties of splines and ways of representing them are discussed. Special attention is paid to the representation of splines as linear combinations of a special set of basic splines, the so-called B-splines.

4. R. Drew Drinkard (DRINK, NUSC) has prepared and given a MACSYMA presentation at NUSC. The presentation is built around a set of viewgraphs of typical problems and their solutions using MACSYMA. Included are second and third order ordinary differential equations, systems of first and second order differential equations, evaluation of definite and indefinite integrals, matrix operations using a Vandermond order three matrix, series expansion in two variables, and an eignvalue problem. Information on specific problems used, availability of the material etc. can be obtained by sending a request via :MAIL DRINK.

5. J.G. Richer (RICHER, NWC) continues to proclaim the benefits of using MACSYMA for circuit analysis. He has developed a library of circuits solved using MACSYMA and circulates examples of MACSYMA circuit solutions (see NALCON MACSYMA Newsletter II, page 13) to colleagues at NWL who have a need. Because the circuits in which MACSYMA is required for analysis are quite complicated and hard to follow, he has developed a simple example, one which can be checked by intuitions, to convince his audience. More information can be obtained by sending a request via :MAIL RICHER.

6. An article entitled "MACSYMA, A Resource for the Navy Laboratories" by Elizabeth Cuthill and Kenton Meals will appear in an upcoming issue of the SIGNUM Newsletter. The article briefly describes NALCON and MACSYMA stressing the advantages of applying MACSYMA as a tool for numerical analysts in developing and testing algorithms. Examples of numerical analysis applications from the Navy MACSYMA community of users are cited.

SECTION V

NALCON MACSYMA USERS

ID	Name	Address
AMENT	Dr. William Ament	NRL, Code 7504
AW	Dr. Abraham Waksman	Temple Univ., Phil., PA
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BJB	Barbara J. Brooks	NRL, Code 1722.6
BP	William G. Parsons	DTNSRDC, Code 1824
CAHM	Dr. George Humfeld	DTNSRDC, Code 187
CARTF	Dr. Forrest L. Carter	NRL, Code 6132
CEPD	Daniel W. Poe	DTNSRDC, Code 1619
CHWA	William R. McCreight	DTNSRDC, Code 1568
CMH	Dr. Cha-Mei Hui	Johns Hopkins, APL Laurel, MD.
CMLEE	Dr. Choung M. Lee	DTNSRDC, Code 1561
DAFEIT	David Feit	DTNSRDC, Code 196
DBNCSL	David Brown	NCSL, Code 732
DRINK	R. Drew Drinkard	NUSC, Code 4424
EISLER	Dr. Thomas Eisler	DTNSRDC, Code 19
ELIZC	Dr. Elizabeth Cuthill	DTNSRDC, Code 1805
FTHEIL	Dr. Feodor Theilheimer	DTNSRDC, Code 1802
HARR	William Harr	NRL, Code 7930
JFJM	John F. MacDonald	NCSL, Code 753
KM	L. Kenton Meals	DTNSRDC, Code 1826
KRUTAR	Dr. Rudolph A. Krutar	NRL, Code 7503
LOPER	Warren E. Loper	NOSC, Code 8221
MEL	Mel Haas	DTNSRDC, Code 1843
MIKWYN	Dr. W. Michael Wynn	NCSL, Code 792
MYLES	Myles Hurwitz	DTNSRDC, Code 1844
NUSCNP	Ronald P. Kasik	NUSC, Code 4451
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RICHER	John G. Richer	NWC, Code 3134
RVE	Richard Van Eseltine	DTNSRDC, Code 1843
SCHULT	Dr. Abraham Schultz	NRL, Code 7932
SIDB	Dr. Sidney Berkowitz	DTNSRDC, Code 1824
WWJ	Dr. Walter Jones	NRL, Code 6750

SECTION VI

MACSYMA References

A. MACSYMA Reference Material available upon request

1. MACSYMA Reference Manual (Dec 1977)
2. MACSYMA Primer (12 Oct 1977)
3. An Introduction to ITS for the MACSYMA User (9 Jan 1977)
4. MACSYMA Notes (10 Jan 1978)
5. PLOT2 Documentation: SHARE; PLOT2 USAGE (11 July 1977) with Appendix from SHARE; PLOT2 RECENT (20 March 1978)
6. NALCON MACSYMA Newsletter (21 Oct. 1977)
7. NALCON MACSYMA Newsletter II (9 March 1978)
8. MACSYMA Course Materials from 6-8 Feb 1978 course
    a. Set of instructors' viewgraphs
    b. Set of problems
    c. A subset of MACSYMA Commands, Switches, and Variables
    d. Reprint: "Algebraic Simplification: A Guide for the Perplexed" by Joel Moses

B. Other MACSYMA Reference Material

1. "MACSYMA - A Resourse for the Navy Laboratory Computer Network" by L. Kenton Meals, DTNSRDC Department Report CMLD-77-04 of January 1977.

2. "Proceedings of the 1977 MACSYMA Users' Conference" NASA Conference Publication NASA CP-2012. Available from National Technical Information Service (NTIS), Springfield, VA 22161, Price $12.50.

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APPENDIX D

SUMMARY OF NALCON MACSYMA USAGE 1 FEB - 31 MARCH 1978

The third bi-monthly questionnaire was sent on 15 April 1978 to all NALCON MACSYMA users who had used the system between 1 February and 31 March 1978. During this period the 3-day MACSYMA course which included terminal sessions for the students, was held at DTNSRDC. A special login name was established for the course. The amount of time charged to this name was 57.3 hours of connect time and 17.9 minutes of run time. Two summaries of total users' time distribution among various categories are shown, one including the course and the other including only individual usage.

In the summary of responses to the questionnaires, continuation of ongoing work reported in earlier surveys is not necessarily included.

- Total Connect Time: 665.5 hours (Including MACSYMA Course)
- Total Run Time: 310.6 minutes
- Percentage of Time

24 Training

14 Demonstration

16 Research & Development

46 Direct Navy Applications

- Total Connect Time: 608.2 hours
- Total Run Time: 292.7 minutes
- Percentage of Time

17 Training

15 Demonstration

18 Research & Development

50 Direct Navy Applications

- Number of Active Individual Users During Period: 25
- Number of New Individual Users During Period: 10
- New applications (not continuation of previously reported application)

  1. Solving simultaneous equations for coordinate transformations used in a data display system.
  2. Trial usage to investigate applicability of MACSYMA to the development of helicopter blade dymanic equations of motion.
  3. Study of radiation from structures with ribs.
  4. Study of attenuation of turbulent boundary layer noise by acoustic blanket.
  5. Use of symbolic techniques for the solution of the Lyapunov-Schmidt branching equation in bifurcation theory.
  6. Circuit analysis for the sidewinder missile.
  7. Preparation of a 45-60 minute presentation demonstrating a wide variety of problems arising in Navy applications that can be solved by MACSYMA.
  8. Use of elliptic functions in circuit calculations for two wire shielded cables.

- Anticipated Applications

  1. Development of helicopter equations requiring extensive coordinate transformations in symbolic form.
  2. Ship motion problems using perterbation methods.
  3. Laplace transforms.
  4. Stability criterion.
  5. State variable analysis.
  6. Circuit design.
  7. Convolution of smoothing functions for modeling energy calculations.

- Work done that would have been impossible or impracticable without MACSYMA.

    1. Development of helicopter equations which require extensive coordinate transformations in symbolic form.

    2. Manipulation and solution of multi variable systems of equations.

    3. Solutions of systems of second order differential equations with initial conditions.

- Work that was done better (more economically, completely, expeditiously) with MACSYMA.

    1. Solving simultaneous equations for coordinate transformations.

    2. Changing and simplifying symbolic equations from vector to scalar format.

    3. Finding limits, computing integrals, and preparing plots.

    4. Evaluation of determinants with polynomial entries.

    5. Solving differential equations and evaluating integrals.

    6. High precision calculations such as those involving large factorials.

- Other significant advantages in using MACSYMA for Navy work.

    1. Extension of capabilities for solving complex math problems more efficiently.

    2. Fast symbolic mathematical manipulations.

    3. MACSYMA has opened new doors in circuit theory. For example, a circuit can be solved for gain and then analyzed to see how gain varies as a function of one or more parameters.

    4. For many problems it is easier and more efficient to use MACSYMA than to write a program in FORTRAN or ALGOL to get a solution. Programs requiring many pages of FORTRAN or ALGOL coding usually require less than one page of MACSYMA code.

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