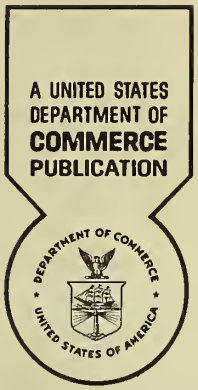

NATIONAL BUREAU OF STANDARDS REPORT

10080

PROJECTS and PUBLICATIONS

of the

APPLIED MATHEMATICS DIVISION

A Semi-Annual Report

January through June 1969

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics [2]—Radio Engineering [2]—Time and Frequency [2]—Astrophysics [2]—Cryogenics.[2]

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

Engineering Standards—Weights and Measures — Invention and Innovation — Vehicle Systems Research—Product Evaluation—Building Research—Instrument Shops—Measurement Engineering—Electronic Technology—Technical Analysis.

THE CENTER FOR RADIATION RESEARCH engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

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Information Processing Standards—Computer Information — Computer Services — Systems Development—Information Processing Technology.

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Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
205.0

NBS REPORT
10080

PROJECTS and PUBLICATIONS

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APPLIED MATHEMATICS DIVISION

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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

APPLIED MATHEMATICS DIVISION FUNCTIONS

Conduct research and provide consulting services to the Bureau and other Federal agencies in various fields of mathematics important to physical and engineering sciences, automatic data processing, and operations research with emphasis on statistical, numerical and combinatorial analysis, and mathematical physics. Develop tools for mathematical work such as mathematical tables, handbooks, manuals, mathematical models and computational methods, and advise on their use. Provide training in disciplines related to these functions.

NUMERICAL ANALYSIS SECTION: The advancement of computation and the theory of numerical analysis, particularly in the development of computing algorithms, approximations to functions, and methods to facilitate the use of high speed electronic computers by subject matter specialists. Design of mathematical tables; exploratory calculations on automatic machines. Consulting services and training, and preparation of manuals in these fields. Research in underlying branches of pure and applied mathematics, such as matrix algebra, combinatorial analysis, and number theory.

OPERATIONS RESEARCH SECTION: Development and application of mathematical and computational techniques for the analysis, improvement or optimization of complex systems or activity-patterns. This includes (1) research in specific relevant areas of mathematics, such as linear programming, the theory of linear graphs, and the theory of strategic contests, (2) investigations in the art of constructing useful mathematical models of complex systems, and of obtaining information about the system by applying analytic or simulation methods, and (3) application of these techniques to selected problems, of general methodological significance, arising in the work of the Bureau or of other Government agencies lacking specialized personnel in this field.

STATISTICAL ENGINEERING SECTION: Consulting services in the application of mathematical statistics to physical science experiments and engineering tests, particularly in the design of experiments and in the analysis and interpretation of data. Research on pertinent topics in probability and mathematical statistics. Preparation of reports, manuals, tables, studies of computational methods and other aids to the application of modern statistical methods.

SYSTEMS DYNAMICS SECTION: Research and consulting in applied mathematics basic to physics and engineering, with emphasis on analysis of the dynamic behavior of complex physical systems. This involves, primarily, the development and application of techniques for solving linear and non-linear systems of differential equations and integral equations, or combinations of both. Of concern also is simulation of the behavior of physical systems by means of electronic computers using approximation techniques and semi-analytic methods. Attention is given to problems in plasma dynamics and the behavior of solid matter and multicomponent liquid systems, with emphasis on developing mathematical methods of wide range of applicability beyond the scope of the immediate problem. Investigations are carried out on the special functions encountered in the analysis and algorithms for their evaluation are prepared.

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°Only unclassified material is included in this report.

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January 1 through June 30, 1969

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California Institute of Technology

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H. O. Hartley, Texas A & M University
M. H. Martin, University of Maryland
Marvin L. Minsky, Mass. Institute of Technology
John Riordan, The Rockefeller University

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Ida Rhodes, M.A., Consultant

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Doris M. Burrell, Sec'y
Karl Goldberg, Ph.D.
Seymour Haber, Ph.D.
Joseph Lehner, Ph.D.*
Frank W. J. Olver, D.Sc.
Edward T. Ordman, M.A.*
Stephen J. Pierce, Ph.D.***
Justin C. Schaffert*

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Roy H. Wampler, M.A.
William H. Youden, Ph.D.***

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Jeffrey T. Fong, Ph.D.
Regina Kopec, Sec'y
S. Richard Kraft, Ph.D.
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Mary H. Snyder, B. A.***

*Part-time
**Postdoctoral Research Associate
***Guest Worker

Status of Projects

1. NUMERICAL ANALYSIS

RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS

Task 20501-12-2050110/55-55

11540

Origin: NBS Authorized 8/29/54
Manager: Morris Newman
Full task description: July - September 1954 issue, p. 1

Status: CONTINUED. M. Newman has determined the genus of the normalizer of certain modular subgroups, generalizing previous work of R. Fricke.

M. Newman and S. Pierce have proved that every left ideal of the complete matrix ring R_n, where R is a principal ideal ring, is principal; and have supplied a partial converse.

M. Newman and S. Pierce have given various criteria for a matrix group to be equivalent to a unitary group: for example, an irreducible matrix group in which the entries in a given position are bounded is such a group.

M. Newman has determined the number of conjugacy classes of $GL(n,q)$. It is the coefficient of x^n in the infinite product

$$\prod_{k=1}^{\infty} \frac{1-x^k}{1-q\,x^k}$$

He has also proved that if A, B are elements of $GL(n,q)$ which are similar over $GL(n,q)$, and if the characteristic polynomial of A is irreducible over $GF(q)$, then A, B are similar over $SL(n,q)$. He has also determined the number of monic irreducible polynomials over $GF(q)$ of degree n and constant term 1($GL(n,q)$ is the group of $n \times n$ non-singular matrices over the finite field $GF(q)$, and $SL(n,q)$ is the subgroup of $GL(n,q)$ consisting of all matrices of determinant 1).

M. Newman, as a check of his program to find the exact solution of an integral linear system, has computed the first factor of the prime cyclotomic fields for all primes under 200. The computation uncovered errors in existing tables of Kummer.

K. Goldberg has found some results for the problem of fitting the 12 distinct pentominoes into a 6×10 rectangle. In a solution let a denote the number of pentominoes which do not touch any side of the rectangle, and let b denote the number of places where four pentominoes meet. Then the graph of the solution has $21 + a-b$ arcs and $10 + a-2b$ complete 3-graphs. Also the solution can be drawn with $34-b$ (interior) straight lines. The evidence indicates that $4 \geq a \geq 0$, $3 \geq b \geq 0$ and $4 \geq a-b \geq -1$.

Status of Projects

K. Goldberg has proved the following result on similarity under composition for formal power series: Let $\alpha = (a_1, a_2, \ldots)$, $\beta = (b_1, b_2, \ldots)$ and $\gamma = (c_1, c_2, \ldots)$ have entries in a field K. Let $f_\alpha(z) = z + a_1 z^2 + a_2 z^3 + \ldots$ and let E_r denote the equation found by equating the coefficients of z^{r+1} in $f_\alpha(f_\gamma(z))$ and $f_\gamma(f_\beta(z))$. If $a_1 = a_2 = \ldots = a_{k-1} = 0$ then E_r implies $b_r = 0$ for $r = 1,2,\ldots, k-1$, and E_k implies $a_k = b_k$. If the characteristic of K is either 0 or $p > k$ then we can solve for c_1 in E_{k+1}, c_2 in $E_{k+2}, \ldots, c_{k-1}$ in E_{2k}. Substituting into E_{2k+1} we get

$$(*) \qquad \det(a_{i+j}) = \det(b_{i+j})$$

where $i,j = 1,2,\ldots, k$ in the indicated matrices. Furthermore we can solve for c_{k+r} (in terms of c_k) in E_{2k+r+1} for $r = 1,2,\ldots, p-1$. As an example of this result suppose K has characteristic 0, $a_j = 0$ for $j = 1,2,\ldots, k-1$ and $a_k \neq 0$. Then $f_\beta(z)$ is similar to $f_\alpha(z)$ if and only if $b_j = 0$ for $j = 1,2,\ldots, k-1$, $b_k = a_k$, and $(*)$ holds.

S. Haber found a construction, using normal numbers, of sequences of numbers that are completely equidistributed to within a specified error.

S. Haber has begun a paper surveying the current literature on numerical evaluation of multiple integrals.

S. Haber showed that the optimal quadrature formulas obtained by the "minimum norm" approach of Sard are identical with those obtained by the "hypercircle" approach used by Golomb and Weinberger. This makes it possible to improve the error bounds on the former formulas, in some situations.

S. Haber and A.J. Goldman found asymptotic expressions for certain functions of delay — minimizing shipping schedules.

F.W.J. Olver has continued his study of the method of steepest descents for evaluating the asymptotic expansions of contour integrals. A weakening of the conditions on the integration path has been achieved and an error analysis constructed. Several illustrative examples have been carried out.

Publications:

(1) On a theorem of Piatetsky-Shapiro and approximation of multiple integrals. S. Haber and C.F. Osgood. Math. Comp. 23, 1969, pp. 165-168.

(2) On the sum $\Sigma < \alpha n >^{-t}$ and numerical integration. S. Haber and C.F. Osgood. To appear in Pacific Jour. of Math.

(3) Stochastic quadrature formulas. S. Haber. To appear in Math. Comp.

(4) Sequences of numbers that are approximately completely equidistributed. S. Haber. Submitted to a technical journal.

(5) Lectures on modular forms. J. Lehner. To appear in J. of Research NBS (as an AMS publication).

(6) On the multipliers of the Dedekind modular function. J. Lehner. To appear in J. of Research NBS.

(7) A theorem on automorphic integrals. J. Lehner. To appear in J. of Research NBS.

(8) Subgroups of SL(t,z). M. Newman. To appear in J. of Research NBS.

(9) Some results on unitary matrix groups. M. Newman and M. Marcus. To appear in J. of Linear Algebra.

(10) Some results on roots of unity, with an application to a diophantine problem. M. Newman. To appear in Aequationes Math.

(11) Isometric circles of congruence groups. M. Newman. To appear in Amer. J. Math.

(12) Principal ideals in matrix rings(with S. Pierce). M. Newman. To appear in J. of Research NBS.

(13) Normal subgroups of the modular group. L. Greenberg and M. Newman. To appear in Bull. Amer. Math. Soc.

(14) Error bounds for the Laplace approximation for definite integrals. F.W.J. Olver. J. of Approximation Theory, vol. 1, 1968, pp. 293-313.

(15) Why steepest descents? F.W.J. Olver. To appear in Proceedings of 1969 SIAM National Meeting, June 10-12, 1969.

(16) A method in diophantine approximation III. C.F. Osgood. To appear in Acta Mathematica (Warsaw, Poland).

(17) A method in diophantine approximation IV. C.F. Osgood. To appear in Acta Mathematica (Warsaw, Poland).

2. OPERATIONS RESEARCH

CONSULTATION IN MATHEMATICAL OPERATIONS RESEARCH

Task 205-12-2050151

Origin and Sponsor: NBS 11570 Authorized 12/30/60
Manager: A.J. Goldman
Full task description: October-December 1960 issue, p.3

Status: CONTINUED.

(1) Demand for miscellaneous consulting and advisory services continued heavy. Section staff provided such services in 97 recorded instances, 45 involving assistance to NBS staff. The 97 instances totalled to 812 recorded man-hours. Other agencies assisted included the Office of Business Economics, Bureau of Labor Statistics, Coast Guard, Civil Service Commission, Arms Control and Disarmament Agency, AEC, NASA, ESSA, and several military laboratories. Requests from universities, industry, professional groups and journals were also met.

(2) J. Gilsinn is assisting the Center for Computer Sciences and Technology in a study, for the Federal Aviation Administration, to improve air traffic designation procedures. A Simscript program has been written to test several schemes for the assignment of radar beacon codes to airplane flights to facilitate automatic identification of individual aircraft.

A.J. Goldman, W.A. Horn, J. Levy and M.H. Pearl are collaborating with the Technical Analysis Division in another study for the FAA, this one to analyze a proposed new "capacity" concept for runways and the associated final approach airspaces. (Reported here for convenience; supported under Projects 6505453 and 4314403 respectively.)

(3) A.J. Goldman, W.G. Hall, W.A. Horn, L.S. Joel and J. Levy continued assistance to the Post Office Department's Bureau of Research and Engineering. Monitoring aid was supplied for two major contractor efforts. Horn prepared a manuscript generalizing a contractor's findings on the optimal design of sorting networks. (Reported here for convenience; supported under Project 4314449.)

(4) J. Gilsinn continued the study, initiated under Maritime Administration support, of an approach to determining good locations for collection-distribution facilities. The computer program was improved, and additional sensitivity analyses performed.

(5) W.G. Hall continued assistance in developing a simulation model for a highway maintenance depot. He also continued helping the Army Data Field Systems Command in planning, design and numerical analysis aspects of a proposed new tactical artillery-fire control system. He continued assistance to the National Highway Safety Bureau in planning and evaluating the data-systems elements of its activities. (Reported here for convenience; supported under Projects 4565425 and 2050625 respectively.)

(6) J. Gilsinn, A.J. Goldman and L.S. Joel continued assistance to the Urban Mass Transit Administration in reviewing mathematical aspects of contractor reports. (Reported here for convenience; supported under Project 2050642.)

(7) W.A. Horn is preparing a paper describing an approach to selecting an optimum number of alternate jurors for a trial. A.J. Goldman returned to the study of some algebraic questions, showing in particular that any associative ring contains a pair of ideals such that each is the other's set of left annihilators. Goldman participated in the Advisory Task Force on the NBS Metric Study. He also served as Program Chairman of the Operations Research Society's Cost-Effectiveness Section, helping to plan and organize sessions at three National Meetings.

Publications

(1) A.J. Goldman. Fractional container-loads and topological groups. Operations Research 16 (1968), pp. 1218-1221.

(2) A.J. Goldman. Mutually annihilating ideals in rings. To appear in Journal of Research NBS, 73B (1969).

(3) A.J. Goldman and P.R. Meyers. Simultaneous contractification. To appear in Journal of Research NBS, 73B (1969).

(4) W.A. Horn. Some fixed point theorems for compact maps and flows in Banach spaces. Submitted to a technical journal.

(5) W.A. Horn. Convex homotopy. Submitted to a technical journal.

COMBINATORIAL METHODS

Task 205-1202050152

Origin and Sponsor: NBS 11540 Authorized 12/30/60
Manager: Jack Edmonds
Full task description: October-December 1964 issue, p.3; April-June 1962, p.15

Status: CONTINUED.

(1) J. Edmonds prepared a series of lectures on "Submodular functions, matroids, and certain polyhedra". These were presented at the Calgary International Symposium on Combinatorial Structures in June. He developed, in particular, an application to "Edge-disjoint branchings" in networks.

With R. Karp (Univ. of Calif., Berkeley), he developed "Theoretical improvements in algorithmic efficiency for network flow problems".

With E.L. Johnson (IBM), he investigated the combinatorics of duality and projection in matching theory. They did further experiments and refinements on the blossom method, and, with Scott Lockhart, completed a user's manual, "Blossom I: A computer code for the matching problem".

Publications

(1) J. Edmonds and D.R. Fulkerson (RAND). Bottleneck extrema. To appear in J. Combinatorial Theory.

(2) J. Edmonds and O. Shisha (Wright-Patterson A.F.B.). Acute bijections. Submitted to a technical journal.

(3) J. Edmonds and R. Karp. A labeling method for maximum network flows which is bounded by a polynomial in the number of nodes. Submitted to a technical journal.

(4) A.J. Goldman. Optimal locations for centers in a network. To appear in Transportation Science.

LINEAR AND NON-LINEAR PROGRAMMING

Task 205-12-2050153

Origin and Sponsor: NBS 11540 Authorized 12/30/60
Manager: Jack Edmonds
Full task description: October-December 1960 issue, p. 3

Status: CONTINUED.

(1) A.J. Goldman continued studying the minimax error selection of incompletely specified discrete probability distributions, solving the case in which componentwise bounds and a componentwise ranking are simultaneously imposed. He also considered the analogous problem of "minimax adjustment" of a given distribution not meeting prescribed constraints (componentwise bounds, or a ranking, or both).

(2) W.A. Horn studied a problem in convex geometry leading to the following result: In n-space, given a point p interior to the convex hull of a finite set S, there is a constant $R(p)$ such that every closed ball of radius $\geq R(p)$, if it contains p, must also meet S.

(3) P. Saunders and A.J. Goldman are participating in a joint effort, with the Computer Services and Technical Analysis Divisions, to improve the capabilities for linear programming calculations at NBS.

Publications

(1) A.J. Goldman. The minimax transportation problem. Transportation Science 2 (1968), pp. 383-387.

(2) A.J. Goldman. Minimax error selection of a univariate distribution with prescribed componentwise bounds and ranking. To appear in Journal of Research NBS, 73B (1969).

(3) A.J. Goldman. Minimax error adjustment of a univariate distribution to satisfy componentwise bounds and/or ranking. To appear in Journal of Research NBS, 73B (1969).

(4) W.A. Horn. A theorem on convex hulls. To appear in Journal of Research NBS, 73B (1969).

MATHEMATICAL METHODS FOR HIGH SPEED GROUND TRANSPORTATION STUDY

Task 205-12-2058456

Origin: Technical Analysis Division, NBS 51550
Sponsor: Northeast Corridor Transportation Project, Dept. of Transportation
Manager: A.J. Goldman

Full task description: January-June 1966 issue, p.14

Status: CONTINUED.

(1) Staff members prepared memoranda on a number of phases of the project, including reviews of several contractors' reports.

(2) P. Saunders continued work on integrating rail scheduling algorithms and demand forecasting models. An improved scheduling method developed at M.I.T. was brought to operational status on the NBS computer. Mrs. Saunders also implemented a dynamic programming model for optimal capital investment over several time periods. It permits several levels of intensity for each of the proposed "projects", and pairwise cost-benefit interactions among projects. As a special study, a dynamic programming algorithm was applied to help select optimal combinations of improvements in the Corridor rail system.

(3) A.J. Goldman and L.S. Joel (with R. Ku of the Technical Analysis Division) studied a number of possibilities for improving the present demand estimation models. J. Gilsinn prepared a working paper summarizing various uses of these models in the Corridor Project, and the resulting requirements on the models.

(4) J. Levy and M.H. Pearl continued developing methods for evaluating feedback vs. non-feedback flow regulation at a merge point in a transport network. A report summarizing work on the non-feedback case was issued, and a paper deriving the optimal adaptive control rule for the 2-stream case is in preparation.

(5) J. Gilsinn continued studies on the comparative evaluation of shortest-path algorithms, with emphasis on formulating and testing explanations for the results of previous computational experiments.

(6) W.A. Horn is documenting an approach to the design of transport networks in cases where minimizing the number of access points is of prime concern.

(7) A.J. Goldman and S. Haber (Numerical Analysis Section) are studying asymptotic properties of delay-minimizing schedules for N dispatches. They proved that the minimized delay is asymptotically proportional to $1/N$, and determined the constant of proportionality.

Publications

(1) W.A. Horn. Optimal networks connecting N points in the plane. To appear in Proceedings of Fourth International Symposium (Karlsruhe, Germany; June, 1968) on Traffic Flow.

(2) W.A. Horn. Minimum-length covering by intersecting intervals. Journal of Research NBS 73B (1969), pp.49-51.

(3) J. Levy and M.H. Pearl. The traffic loss at a merge-point controlled by non-feedback regulation. NBS Report 9989 (2/1/69).

3. PROBABILITY AND MATHEMATICAL STATISTICS

RESEARCH IN PROBABILITY AND MATHEMATICAL STATISTICS

Task 20503-12-2050131/63-1259
1150

Origin: NBS Authorized 10/1/62
Manager: Joan Raup Rosenblatt
Full task description: July - December 1962

Status: CONTINUED. Roy H. Wampler is continuing his study of the accuracy of linear least squares computer programs. His most recent results, on the good performance of a Björck-Golub algorithm using Householder transformations, are included in a summary report prepared for the 14th Conference on Design of Experiments in Army Research Development and Testing.

Janace A. Speckman has been collaborating with J. M. Cameron (Office of Measurement Services) and W. H. Clatworthy (University of North Carolina and State University of New York, Buffalo) on preparation for publication of the revised and expanded version of "Tables of Partially Balanced Designs with Two Associate Classes" by Bose, Clatworthy and Shrikhande. Computer programs have been written for checking the tables, for checking the structure of the designs and their association schemes for identifying the dual designs, and for calculating various constants. The output from the computer is being put in the form in which it will finally appear when published.

David Hogben has been collaborating with John Mandel and Mary N. Steel (Institute for Materials Research) on the development of a general method for obtaining non-linear approximations to tabulated functions, for use in computer programs. Methods developed by Mandel for representation of experimental data have been applied to obtain approximations for several statistical functions, since storage of tabulated functions in electronic computers is often impractical because of limitations of storage space and the difficulty of interpolation. For one-way tables of monotonic functions, such as tabulations of control chart constants, the approximations use a four-parameter model fitted by non-linear least squares. Approximations to two-way tables, such as a tabulation of the studentized range, involve a fitting of eigenvectors, derived from the row by column interaction matrix, to functions of the row and column variables. The results are particularly useful for two-way tables where mathematical theory of rational or polynomial approximations has not been developed.

H. H. Ku has collaborated with C. T. Ireland and S. Kullback (George Washington University) on an investigation of methods for testing symmetry and marginal homogeneity of an r x r contingency table. The principle of minimum discrimination information estimation is employed to obtain RBAN (Regular Best Asymptotically Normal) estimates of the cell frequencies of an r x r contingency table under hypotheses of symmetry and marginal homogeneity. For the latter a convergent iterative procedure is given to compute the estimates. The associated minimum discrimination information statistics (m. d. i. s.) are distributed asymptotically as χ^2 under the null hypothesis. The procedures differ from those previously presented in the literature and permit of extension to multidimensional contingency tables. Using the properties of the m.d.i.s., it is proved that an r x r table is symmetric if and only if it has marginal homogeneity and quasi-symmetry. Quasi-symmetry, defined by Caussinus, obtains when there exist numbers a_i, b_j, $c_{ij} = c_{ji}$ such that the elements x_{ij} of the table have the form

$$x_{ij} = a_i b_j c_{ij} \quad (i,j = 1, \ldots, r).$$

Publications:

(1) The median significance level and other small sample measures of test efficacy. B. L. Joiner. To appear in J. Amer. Statist. Assoc.

(2) Student-t deviate corresponding to a given normal deviate. B. L. Joiner. To appear in J. Res. NBS - C. Engineering and Instrumentation.

(3) Precision Measurement and Calibration, Vol. 1 - Statistical Concepts and Procedures. H. H. Ku, ed. NBS Spec. Pub. 300, February 1969.

(4) Approximating discrete probability distributions. H. H. Ku and S. Kullback (G.W.U.). To appear in IEEE Transactions on Information Theory.

(5) Analysis of multi-dimensional contingency tables. H. H. Ku, R. N. Varner and S. Kullback (George Washington Univ.). To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

(6) An application of minimum discrimination information estimation to a problem of Grizzle and Berkson on the test of "no interaction" hypothesis. H. H. Ku and S. Kullback (G.W.U.). Submitted to a technical journal.

(7) Symmetry and marginal homogeneity of an r x r contingency table. C. T. Ireland, S. Kullback (G.W.U.), and H. H. Ku. Submitted to a technical journal.

(8) An evaluation of linear least squares computer programs. Roy H. Wampler. To appear in J. Res. NBS-B. Math. Sciences.

(9) An evaluation of linear least squares computer programs: A summary report. Roy H. Wampler. To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

(10) A report on the accuracy of some widely used least squares computer programs. Roy H. Wampler. Submitted to a technical journal.

DEVELOPMENT OF "OMNITAB"

Task 20503-12-2050131
11550

Origin and Sponsor: NBS Authorized 11/1/68
Managers: David Hogben, Sally T. Peavy
Full task description: July - December 1968

Status: CONTINUED. Three new versions of OMNITAB have been implemented successively. The first revision (version 3.05) incorporated major changes including overlay and segmentation features to give a worksheet two and a half times as big as the previous one. Altogether, 43 new instructions were added, including a comprehensive set of 34 instructions to compute Bessel functions of order zero and order one for either real or complex argument, Bessel functions of order n, an integral of a Bessel function, and zeros of Bessel functions. The other instructions included ones to: compute elliptic and Struve integrals, print data in a readable form, rank data, perform a harmonic analysis, and perform a statistical analysis of a two-way table. The latter gives an automatic printing of results in readable form, i.e. with the decimal point in a constant position determined by the data. Several minor improvements were made in other instructions.

To keep OMNITAB users informed of latest developments, the first in a series of Newsletters was issued. An annotated list of OMNITAB commands, available in NBS version 3.05, has been prepared by Brian L. Joiner as a temporary supplement to the OMNITAB manual, NBS Handbook 101.

Approximately 75 requests per month for assistance are being answered. Several computer installations have requested copies of the program tape, and have obtained assistance toward implementing OMNITAB.

4. STATISTICAL ENGINEERING SERVICES

COLLABORATION ON STATISTICAL ASPECTS OF

NBS RESEARCH AND TESTING

Task 13911-612050950/51-1
99500

Origin: NBS Authorized 7/1/50
Managers: H. H. Ku, J. R. Rosenblatt
Full task description: July - September 1950 issue, p. 60

Status: CONTINUED. This is a continuing project involving cooperation with other Bureau scientists on the statistical aspects of their investigations. These services vary from short (one-hour) sessions to extended collaborations involving several man-months; and are concerned primarily with statistical design of experiments, analysis and interpretation of data, and the use of computers in statistical analysis of data. Typical examples of the services performed are the following.

During the ten year period 1959-69, the Statistical Engineering Laboratory has provided continuous support and service to the Analytical Mass Spectrometry Section on a project dealing with the determination of atomic weights by direct measure of absolute isotopic ratios. To date, NBS values for the atomic weights of six elements (Silver, Magnesium, Copper, Chromium, Chlorine, and Bromine), and their respective evaluated uncertainties, have been adopted by the International Commission on Atomic Weights. Atomic weight for a seventh element, Rubidium, will be submitted to the Commission this summer.

The methods used in evaluation of uncertainties were described by H. H. Ku in an Appendix, "Statistical Evaluation of Uncertainties Associated with the Reported Values," published in Analytical Mass Spectrometry Section: Instrumentation and Procedures for Isotopic Analysis, NBS Tech. Note 277, 1966.

H. H. Ku assisted W. B. Mann (Radioactivity Section, Center for Radiation Research) in the analysis of uranium miner's safety data in preparation of a position memorandum for the Interagency Uranium Mining Radiation Review Group, to be submitted to the Federal Radiation Council.

Roy H. Wampler and other members of the staff participated in a meeting arranged by the NBS Equation of State Section, bringing together specialists from about a dozen university, industrial, and government laboratories to discuss the experimental problems of the Burnett method of PVT measurement and especially the computational problems (nonlinear least squares) of reducing the measured pressure data to compressibility factors and virial coefficients. Mr. Wampler presented a talk on pitfalls in the use of packaged least squares programs.

Brian L. Joiner has assisted in the testing work leading to the certification of several Standard Reference materials including SRM 953 Neutron Density Monitor Wire, SRM's 1090, 1091, 1092 Oxygen in Ferrous Materials, SRM 1094 Oxygen in Maraging Steel, SRM 1651 barium chromate-zirconium heat-source calorimetry, SRM 725 Mossbauer Differential Chemical Shift, SRM 122 Cast iron certified for 13 elements, and SRM 84 acid potassium phthalate acidimetric standard.

Collaboration with the SRM program is continuing and efforts are being made to improve the planning of the testing to obtain better information on the relative homogeneity of the materials and to improve the reporting of results on the certificate.

David Hogben assisted John Evans and Sherril Dittman in the design and analysis of an experiment to compare resistance thermometers and pairs of thermocouples in the temperature range 650 to 1000°C, part of the high temperature resistance thermometry program of the Heat Division.

H. H. Ku assisted A. F. Robertson (Fire Research and Safety Office) in the design and analysis of fire tests of deck covering materials used by the Intergovernmental Maritime Consultative Organization. Joan R. Rosenblatt assisted J. A. Rockett of the same Office in planning for statistical aspects of future programs.

Publications:

(1) The statistical consultant in a scientific laboratory. J. M. Cameron. Technometrics, Vol. 11 (1969), pp. 247-254.

(2) Fitting of multiple line Mossbauer spectra using constraints. J. C. Travis (Radiochemical Analysis section) and B. L. Joiner. Section 3H (pages 68-75) and Appendix I (pages 117-119) in Radiochemical Analysis Section: Summary of Activities July 1967 to June 1968, edited by James R. DeVoe, NBS Technical Note 451, January 1969.

(3) Interlaboratory comparison of the potential heat test method. D. Gross (Fire Research Section) and M. G. Natrella. Submitted to a technical journal.

(4) A survey of blemishes on government microfilm. C. S. McCamy (Image Optics and Photograph Section), R. S. Wiley (Army Map Service), and J. A. Speckman. J. Res. NBS - Phys. and Chem., Vol. 73A, Jan.-Feb. 1969, pp. 79-98.

STATISTICAL SERVICES

Task 20503-40-2050132/58-346
11550

Origin and Sponsors: Various Agencies Authorized 3/31/58
Manager: J. R. Rosenblatt
Full task description: January - March 1958 issue, p. 45

Status: CONTINUED. This is a continuing project which involves providing, upon request, statistical services to other governmental agencies, universities, industrial organizations, and other non-governmental agencies. Approximately 30 such requests are handled per month ranging from short conferences to collaboration involving several days work.

Information about computer programs and other aspects of statistical computing was provided for the Bureau of Engineering and Physical Sciences, National Air Pollution Control Administration.

The Committee on Mathematical Tables of the Institute of Mathematical Statistics announced in June 1968 that it had established a project to publish a series of tables of functions useful for statisticians. Roy H. Wampler, as a member of this committee, has been serving on the editorial board which reviews the manuscripts submitted for publication.

A briefing on OMNITAB was given for the Chief Statistician of the D. C. Government, together with members of his staff, and representatives of the D. C. Office of Crime Analysis and of the Washington area Council of Governments. Joan Rosenblatt, Brian Joiner, and Sally Peavy participated and were joined by Joseph Hilsenrath (Office of Standard Reference Data) who described his recent general-purpose text editing programs.

5. SYSTEMS DYNAMICS SECTION

RESEARCH IN MATHEMATICAL PHYSICS

AND RELATED FIELDS

Task 20540-12-2050141/55-57
11540

Origin: NBS Authorized 9/1/54
Manager: H. J. Oser
Full Task description: July-September 1954 issue, p. 27

H. J. Oser continued his cooperative work with other Divisions, particularly the Mechanics Division and the Metrology Division. A manuscript entitled "Stability of Acoustic Waves within a Viscous, Compressible, Heat-Conducting Fluid" completed with J. E. McKinney of 213.05 (Rheology Section) was sent to the Journal of the Acoustical Society of America for publication. A second manuscript which is concerned with the mathematical aspects of the problem is undergoing Division Review.

J. T. Fong continued to investigate the mathematical structure of modern theories of metals and polymers, with emphasis on the inter-relationship between the approach due to Kondo, Kroner, Bilby, etc. based on crystal imperfections and that due to Truesdell, Noll, Wang, etc. based on the assumption of "simple" materials. In particular, J. T. Fong and Dr. J. A. Simmons of the Metallurgy Division, I.M.R., generalized the classical formulation of a stationary problem by working with an anholonomic functional $\overline{\delta F}$ where F does not exist in the classical sense. Instead of the well-known Euler equations which are necessary and sufficient for the classical stationary problem, one obtains integral equations which are path dependent. A manuscript entitled "On a generalization of the classical stationary problem in variational calculus" is being prepared for review and discussion.

R. S. Kraft developed a method of establishing convergence and decay rates for semi-discrete approximations of linear transport problems. A paper containing these results is being prepared for publication. Research is continuing in this area in an attempt to apply the above method to establish convergence of semi-discrete approximations of various types of partial differential equations.

A method has been found of obtaining power series expansions of certain problems for the linear or nonlinear one dimensional wave equation. Applications are being investigated.

A positive-definite energy expression has been found for the electrical energy in a discretized version of the Nernst-Planck equations. Positive-definite expressions for the total energy are being sought.

D. W. Lozier investigated the problem of writing an improved automatic numerical integration routine for OMNITAB and developed two preliminary computer programs. He also provided computer programming support for W. L. Sadowski and other staff members of NBS. A paper is now being completed with the title "Frechet Differential Calculus". It will be submitted to American University in fulfillment of requirements for an MA degree. He presented part of this material in four informal Section seminars during April and May.

Z. G. Ruthberg took initial steps for implementing a stepped-up program on evaluation, testing and creation of computer algorithms for special functions in applied mathematics and computational methods of linear algebra. This program is designed to produce comparative evaluations of such algorithms which will be made available on a timely basis to users of electronic computers.

A number of exploratory sessions were held with P. E. Pontius and H. A. Bowman of 213.31 (Mass and Volume Section) to study new approaches for high-precision volumetric determinations. The problem consists in determining the precise volume of a nearly perfect sphere, the uncertainties in radius being of the order of 10^{-6} x radius. The exact knowledge of a volume is necessary for determinations of density, viscosity, Avogadro's number and volumes of other bodies once a fluid of precisely known density is on hand.

Publications:

(1) An Unusual Mixed Initial Boundary Problem in Two Independent Variables. R. Kraft. Jour. of Math. Analy. & Appl., Vol. 25, No. 2, Feb. 1969.

(2) Stability of Acoustic Waves within a Viscous, Compressible, Heat-Conducting Fluid. J. E. McKinney and H. J. Oser. To appear in the Jour. of Acoustical Society of America.

PLASMA PHYSICS

Task 20504-12-2050140/59-442
11540

Origin: NBS Authorized 10/13/61
Manager: H. J. Oser
Full task description: October-December 1961 issue, p. 12

W. L. Sadowski specialized to the non-linear Vlasov equation the combinatorial method of calculating the Taylor expansion in time of a solution of a partial differential equation. Selection rules were developed to eliminate the combinatorial terms in the general treatment that do not occur in the special problem. A program to calculate the Taylor expansion coefficients recursively was written and tested. The program gives information on the radius of convergence of the truncated Taylor series and will also be used to check the results that will be obtained combinatorially.

Two manuscripts by W. L. Sadowski together with Z. G. Ruthberg, entitled "Temperature Renormalization in the Non-Linear Vlasov Equation" and "Selective Excitation of Harmonics in a Collisionless Plasma by Two Counterstreaming Electron Beams" were submitted to the editorial committee of NBS.

W. L. Sadowski and Z. G. Ruthberg investigated partial differential operators from the combinatorial point of view and are exploring the feasibility of using LISP programming to test the approach for its usefulness.

Publications

(1) Temperature Renormalization in the Non-Linear Vlasov Equation. W. L. Sadowski and Z. G. Ruthberg. To appear in Jour. of Research NBS.

(2) Selective Excitation of Harmonics in a Collisionless Plasma by Two Counterstreaming Electron Beams. W. L. Sadowski and Z. G. Ruthberg. To appear in Jour. of Research NBS.

BIOMEDICAL IMAGE AND LANGUAGE PATTERN PROCESSING

Task 20500-12-2050404

51560

Origin: NBS Authorized 1/21/64
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch
Full task description: January-June 1964 issue, p. 19

Status: CONTINUED. Further refinements on the scanning microscope were built. Programs were written on the Q32 computer to accept data from the microscope on paper tape. Several analyses from photographic data were made for single neurons in tissue sections. Some initial work was done to convert the LISPAX system from the Q32 computer to the PDP-10 computer at NIH.

SCANNING MICROSCOPE PROCESSING

Task 20500-2050408

51560

Origin: NBS Authorized 6/18/68
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch

Status: CONTINUED. Scanning microscope data for white cells were prepared for use in the Q32 computer. Morphological analyses were done for a neutrophile. The PDP-10 was used to convert this data to display form and used to present the data in picture and numerical format.

CHEMICAL BIOLOGICAL INFORMATION PROCESSING

Task 20500-2050410

51560

Origin: NBS Authorized 6/27/68
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch

Status: CONTINUED. Advisory work continued on Chemical Biological Information Handling Techniques. The use of the Q32 facility was provided to the sponsor for file handling experiments.

MATHEMATICAL TABLES

Task 20500-40-2050121/57-216

11550

Origin and Sponsor; NBS
Manager: I. A. Stegun
Full task description: July-December 1964 issue, p. 4.

Status: CONTINUED. The updating of bibliographic material and correction lists continued for all published volumes. Material has been prepared for an eighth corrected printing of AMS 55- the Handbook of Mathematical Functions.

Assistance at the rate of ten consultations per month to NBS, other government agencies, industry and universities was offered in the evaluation or modification of computing techniques, identification of functions and their tabulation.

I. A. Stegun and R. Zucker have programmed an automatic computing method for evaluating general power series, asymptotic expansions and continued fractions. This program is being utilized to explore practical regions of convergence, loss of significance and round-off errors. A particular study was made of the computing methods for the error and complementary error integral. A special code was written for computing these functions to maximum machine accuracy.

Lectures and Technical Meetings

Statistics Seminar

PEARSON, E. S. (University of London) Some Historical Reflections, Traced Through the Development and Use of Frequency Curves. May 2.

Mathematical Statistics Seminars

FILLIBEN, J. J. (Princeton University) Linear Estimation of the Location Parameter of a Symmetric Distribution. April 23.

WILKINSON, G. N. (C.S.I.R.O., Australia) A General Recursive Procedure for Analysis of Variance. May 13.

BJÖRCK, Å. (Royal Institute of Technology, Sweden) Linear Least Squares, Problems and Methods. June 24.

Mathematics Division Expository Lectures

OSER, H. The Problems of Our Cities, a Recent M.I.T. Effort in Mathematical Modelling. February 5.

HORN, W. A. Optimal Networks Joining End Points in the Plane. February 19.

NEWMAN, M. The Geometry of Numbers. March 26.

HAYES, J. G. (National Physical Laboratory, England) Methods of Curve and Surface Fitting With Polynomials. April 24.

PIERCE, S. J. Generalized Matrix Functions. May 7.

FONG, J. T. On the Application of Differential Geometry in Continuum Physics. May 21.

GAUTSCHI, W. (Computer Sciences, Purdue University, Lafayette, Indiana) An Extension of Gaussian Quadrature with an Application to the Computation of Highly Oscillatory Integrals. June 13.

PEARL, M. On Generalized Inverses. June 20.

HABER, S. Numerical Evaluation of Multiple Integrals. June 24.

Systems Dynamics Seminar

BERMAN, Mones (Mathematical Research Branch, Natl. Inst. of Arthritis and Metabolic Diseases, NIH.)

SAAM Program and its Uses in the Study of Metabolic and Kinetic Systems. October 9.

PLOTKIN, A. (Dept. of Aerospace Engineering, University of Maryland. A Numerical Solution for the Laminar Wake Behind a Finite Flat Plate. November 13.

HEARON, John Z. (Math. Research Branch, Natl. Inst. of Arthritis and Metabolic Diseases, NIH) Generalized Inverses and Linear Systems of Equations. December 11.

CRISTESCU, Nicolae (Prof. of Mechanics, Univ. of Bucharest and the Math. Inst. of the Academy of the Socialist Republic of Romania and currently Visiting Professor of Department of Mechanics, Johns Hopkins University)

Some Mathematical Problems of the Mechanics of Extensible Strings. Jan. 8.

COLNER, Donald R. (Technical Analysis Division, NBS) On the Application of Functional Analysis to the Finding of Periodic Solutions of Nonlinear Diffusion Equation. Two Parts - January 23 and February 5.

COLNER, Donald R. (Technical Analysis Division, NBS) On the Application of Functional Analysis to the Finding of Periodic Solutions of Nonlinear Diffusion Equation. February 12.

NEWMAN, Morris — (Chief, Numerical Analysis Section, Applied Mathematics Division, NBS) Solving Equations Exactly. February 12.

ADEM, Julian — (Weather Bureau, Environmental Science Services Administration) Theromodynamics Approach to Long-Range Weather Prediction. March 12.

WANG, Henry — (Fluid Dynamics Branch, Naval Ship Research and Development Center) Viscous Flow in a Cylindrical Tube Containing a Line of Spherical Particles. April 9.

THURAISAMY, V. — (Belcomm Inc., Washington, D.C.) Discrete Analogues for the Third Boundary Value Problem. May 14.

Statistical Computing Made Easy for Nonprogrammers

An expository seminar on OMNITAB arranged by the Washington Statistical Society and cosponsored by the Washington Operations Research Council and the Washington Chapters of the Institute of Management Sciences and the Association for Computing Machinery, Washington, D. C., April 2.

HILSENRATH, J. — (NBS Office of Standard Reference Data) OMNITAB: Design, Motivation, Rewards.

JOINER, B. L. — Basic OMNITAB.

HOGBEN, D. — Why OMNITAB?

PEAVY, S. T. — Ground Rules.

JOINER, B. L. — Power and Flexibility Disclosed.

HOGBEN, D. — Instructions for Statistical Computing.

CAMERON, J. M. — (NBS Office of Measurement Services) Matrix and Array Operations.

ROSENBLATT, J. R. — Exploratory Data Analysis.

Demonstration of
On-line OMNITAB (Maryland University)

MESSINA, C. G. — (NBS Office of Standard Reference Data)

GILBERT, W. J. — (University of Maryland)

In-Hours Courses, Spring Semester

PEAVY, Sally T. — New Topics in FORTRAN.

Papers and Invited Talks Presented by Members of the Staff at Meetings of Outside Organizations

EDMONDS, J. R.	Polyhedral Aspects of Matroids. IBM Research, Yorktown Heights, New York. April 2.
	Polyhedral Aspects of Matroids. Rockefeller University, New York, New York. April 7.
EDMONDS, J. R.	Submodular Functions, Matroids, and Certain Polyhedra. Lectures given at Calgary International Symposium, Canada. June 2, 13.
GILSINN, J. F.	Finding Good Consolidation Points. SIAM General Meeting. The Shoreham Hotel, Washington, D. C. June 11.
GOLDMAN, A. J.	Discussant, Session on City Management. Washington Operations Research Council Symposium, NBS. May 27.
GOLDMAN, A. J.	Minimax Adjustment of a Univariate Distribution with Prescribed Componentwise Bounds and/or Ranking. SIAM General Meeting. Shoreham Hotel, Washington, D.C. June 12.
GOLDMAN, A. J.	Asymptotic Properties of Delay-Minimizing Schedules. ORSA National Meeting, Denver, Colorado. June 19.
HOGBEN, D.	OMNITAB -- A Computer Program for Numerical, Statistical and Data Analysis. UNC-NSF Summer Workshop, Instructional Use of Computers in Statistics, University of North Carolina, Chapel Hill. June 18.
HORN, W. A.	Optimal Container Inventory and Routing. ORSA National Meeting, Denver, Colorado. June 19.
JOINER, B. L.	Statistical Analysis of Test Data. Testing of Plastics Workshop, Center for Professional Advancement, Saul Gordon Associates. Morristown, N. J. Feb. 25.
JOINER, B. L. and ROSENBLATT, J. R.	Nonlinear Least Squares. NBS Atomic and Molecular Physics Division Colloquium. April 10.
KIRSCH, R. A.	Pictorial Information Processing. Psychopictorics Symposium. April 15.
KIRSCH, R. A.	Computer Measurements of Image Structure. NIH-NBS Joint Colloquium. May 20.
KU, H. H.	Analysis of Multi-dimensional Contingency Tables. Virginia Academy of Science, Fredericksburg, Va. May 9.
MEYERS, P. R.	Simultaneous Contractification. Meeting of American Math. Soc., University of California at Santa Cruz. April 26.
NEWMAN, M.	Solving Equations Exactly. Presented to the Gatlinburg IV Conference, Gatlinburg, Tennessee. April 14.
OLVER, F. W. J.	Why Steepest Descents? Presented to the 1969 SIAM National Meeting, Shoreham Hotel, Washington, D. C. June 10-12.
ROSENBLATT, J. R.	Analysis of Straight Line Data: The Effect of a Cumulative Error Component. Johns Hopkins University. January 15.
SPECKMAN, J. A.	The Role of a Statistician at the NBS. Hollins College. April 18.
WAMPLER, R. H.	Pitfalls in the Use of Packaged Least Squares Programs. Meeting of the Burnett Method of PVT Measurements, sponsored by NBS Equation of State Section, Gaithersburg. February 28.

PUBLICATIONS ACTIVITIES

1.0 PUBLICATIONS THAT APPEARED DURING THIS PERIOD

1.3 Technical Papers

The Statistical Consultant in a Scientific Laboratory. J. M. Cameron. Technometrics, Vol. 11 (1969), pp. 247-254.

On a Theorem of Piatetsky-Shapiro and Approximation of Multiple Integrals. S. Haber and C. F. Osgood. Math. Comp. 23,(1969), pp. 165-168.

Minimum Length Covering by Intersecting Intervals. W. A. Horn. J. of Research NBS, 73B, p .49-51 (1968).

An Unusual Mixed Initial Boundary Problem in Two Independent Variables. R. Kraft. J. of Math. Analy. & Appl. Vol. 25, No. 2. (Feb. 1969).

A Survey of Blemishes on Government Microfilm. C. S. McCamy (Image Optics and Photograph Section), R. S. Wiley (Army Map Service), and J. A. Speckman. J. Res. NBS. Phys. and Chem. Vol. 73A, Jan.-Feb. 1969, pp. 79-98.

Error Bounds for the Laplace Approximation for Definite Integrals. F. W. J. Olver. J. of Approximation Theory, Vol. 1, 1968, pp. 293-313.

Toward an Algebraic Characterization of Convex Polyhedral Cones. R. J. B. Wets and C. Witzgall. Numerische Math. 12 (1968), pp. 134-138.

1.4 Notes

The Minimax Transportation Problem. A. J. Goldman. Transportation Science, 2 No. 4, 383-387 (November 1968).

Fractional Container-Loads and Topological Groups. A. J. Goldman. Operations Research Vol. 16, No. 6, 1218-1221 (Nov.-Dec. 1968).

Fitting of Multiple Line Mossbauer Spectra Using Constraints. J. C. Travis (Radiochemical Analysis Section) and B. L. Joiner. Section 3H (pp. 68-75) and Appendix I (pp. 117-119) in Radiochemical Analysis Section: Summary of Activities July 1967 to June 1968, edited by James R. DeVoe, NBS Technical Note 451, January 1968.

1.5 Books

Precision Measurement and Calibration, Vol. 1 - Statistical Concepts and Procedures. H. H. Ku ed. NBS Spec. Pub. 300, February 1969.

2.0 MANUSCRIPTS IN THE PROCESS OF PUBLICATION

2.3 Technical Papers

Minimax Error Selection of Univariate Distribution with Prescribed Componentwise Bounds and Ranking. A. J. Goldman. To appear in J. of Research NBS, 73B (1969).

Minimax Error Adjustment of a Univariate Distribution to Satisfy Componentwise Bounds and/or Ranking. A. J. Goldman. To appear in J. of Research NBS, 73B (1969).

Interlaboratory Comparison of the Potential Heat Test Method. D. Gross (Fire Research Section) and M. G. Natrella. Submitted to a technical journal.

Stochastic Quadrature Formulas. S. Haber. To appear in Math. Comp.

Sequences of Numbers that are Approximately Completely Equidistributed. S. Haber. Submitted to a technical journal.

Determining Optimal Inventory and Routing. W. A. Horn. Proceedings of the 35th National Meeting of the O.R.S. Denver, Colorado. June 1969.

The Median Significance Level and Other Small Sample Measures of Test Efficacy. B. L. Joiner. To appear in J. Amer. Statist. Assoc.

Stability of Acoustic Waves Within a Viscous, Compressible Heat-Conducting Fluid. John McKinney (Mechanics Division) and Hans J. Oser. To appear in J. Acoust. Soc. Am.

Subgroups of SL(t,z). M. Newman. To appear in J. of Research NBS.

Some Results on Unitary Matrix Groups. M. Newman and M. Marcus. To appear in J.of Linear Algebra.

Some Results on Roots of Unity, with an Application to a Diophantine Problem. M. Newman. To appear in Aequationes Math.

Isometric Circles of Congruence Groups. M. Newman. To appear in Amer. J. Math.

Principal Ideals in Matrix Rings. M. Newman and S. Pierce. To appear in J. of Research NBS.

A Method in Diophantine Approximation IV. C. F. Osgood. To appear in Acta Mathematica (Warsaw, Poland).

An Evaluation of Linear Least Squares Computer Programs. Roy H.Wampler. To appear in J. Res. NBS - B. Math. Sciences.

An Evaluation of Linear Least Squares Computer Programs: A Summary Report. Roy H. Wampler. To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

A Report on the Accuracy of Some Widely Used Least Squares Computer Programs. Roy H. Wampler. Submitted to a technical journal.

Student-t Deviate Corresponding to a Given Normal Deviate. B. L. Joiner. To appear in J. Res. NBS - C. Engineering and Instrumentation.

Approximating Discrete Probability Distributions. H. H. Ku and S. Kullback (G.W.U.). To appear in IEEE Transactions on Information Theory.

Analysis of Multi-Dimensional Contingency Tables. H. H. Ku, R. N. Varner and S. Kullback (G.W.U.). To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

An Application of Minimum Discrimination Information Estimation to a Problem of Grizzle and Berkson on the Test of "No Interaction" Hypothesis. H. H. Ku and S. Kullback (G.W.U.). Submitted to a technical journal.

Symmetry and Marginal Homogeneity of an r x r Contingency Table. C. T. Ireland, S. Kullback (G.W.U.), and H. H. Ku. Submitted to a technical journal.

Lectures on Modular Forms. J. Lehner. To appear in J. of Research NBS (as AMS).

On the Multipliers of the Dedekind Modular Function. J. Lehner. To appear in J. of Research NBS.

A Theorem on Automorphic Integrals. J. Lehner. To appear in J. of Research NBS.

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

• Physics and Chemistry

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75*.

• Mathematical Sciences

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

• Engineering and Instrumentation

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $3.00; foreign, $4.00*.

* Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications. Proceedings of NBS conferences, bibliographies, annual reports, wall charts, pamphlets, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitive data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89–306, and Bureau of the Budget Circular A–86 entitled, Standardization of Data Elements and Codes in Data Systems.

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