THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section is engaged in specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside of the back cover of this report.


Radio Standards. High Frequency Standards. Microwave Standards.

- Office of Basic Instrumentation
- Office of Weights and Measures
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*Only unclassified projects are included in this report.
PROJECTS and PUBLICATIONS of the
APPLIED MATHEMATICS DIVISION

January through March, 1956
APPLIED MATHEMATICS DIVISION
January 1 through March 31, 1956

TECHNICAL ADVISORY COMMITTEE

David Blackwell, Howard University
Edward U. Condon
Mark Kac, Cornell University

Philip M. Morse, Massachusetts Institute of Technology
Mina S. Rees, Hunter College
A. H. Taub, University of Illinois

DIVISION OFFICE

Edward W. Cannon, Ph.D., Chief
Franz L. Alt, Ph.D., Assistant Chief
Olga Taussky-Todd, Ph.D., Consultant
W. J. Youden, Ph.D., Consultant
Myrtle R. Kellington, M.A., Technical Aid
Luis O. Rodriguez, M.A., Administrative Officer
Yates S. Sladen, Administrative Assistant
Marguerite C. Hepburn, Secretary
Mary E. McKinley, Secretary

NUMERICAL ANALYSIS SECTION

Henry A. Antosiewicz, Ph.D.
*N. Aronszajn, D.Sc.
Philip Davis, Ph.D.

John Todd, B.S., Chief

Karl Goldberg, M.A.
Evelyn A. Grigg, Sec'y

Alan J. Hoffman, Ph.D.
Morris Newman, Ph.D.

COMPUTATION LABORATORY

Joseph Bram, Ph.D.
Hans O. Bremer, B.A.
William F. Cahill, M.S.
Ruth E. Capuano
John W. Cooper, B.S.
Mary M. Dunlap, B.S.
Robert L. Durrah, M.A.
Elizabeth F. Godefroy
William G. Hall, B.S.
Genevie E. Hawkins, B.S.
Emilie V. Haynsworth, Ph.D.

Milton Abramowitz, Ph.D., Chief
Irene A. Stegun, M.A., Assistant Chief

*Urs W. Hochstrasser, Ph.D.
Gloria F. Holmes, B.S., Sec'y
Dorothea H. Jirauh, M.A.
Lambert S. Joel, B.A.
David S. Liepmann
Ethel C. Marden, B.A.
Kermit C. Nelson
Peter J. O'Hara, B.S.
Mary Orr
Maxine L. Paulsen, B.S.

Sally T. Peavy, B.S.
B. Stanley Prusch
Elizabeth A. Radcliffe
Ida Rhodes, M.A.
Billie G. Urban, M.S.
Philip J. Walsh, B.S.
Bertha H. Walter
Joseph H. Wegstein, M.S.
Richard G. Williams, M.S.
Ruth Zucker, B.A.

STATISTICAL ENGINEERING LABORATORY

Churchill Eisenhart, Ph.D., Chief
Joseph M. Cameron, M.S., Assistant Chief

Robert C. Burton
Marion T. Carson
William S. Connor, Ph.D.
Mary C. Dannemiller
Lola S. Deming, M.A.

Mary L. Epling, B.S.
Lela J. Hamilton, Sec'y
Julius Lieblein, Ph.D.
Mary G. Natrella, B.A.
Joan R. Rosenblatt, Ph.D.

***Norman C. Severo, Ph.D.
*Paul N. Somerville, Ph.D.
Carolyn Yick, Sec'y
Marvin Zelen, M.A.

MATHEMATICAL PHYSICS SECTION

Robert F. Dressler, Ph.D., Chief

Peter Chiarulli, Ph.D.
Leon Feldman, B.A.
*Peter Henrici, Ph.D.

*Fritz Oberhettinger, Ph.D.
Edith N. Reese, B.A.
Lillian Sloane, Sec'y

**Robert Stoneley, Sc.D.
*John L. Synge, Sc.D.

*Under contract with The American University **Guest Worker ***On leave of absence
STATUS OF PROJECTS
March 31, 1956

1. NUMERICAL ANALYSIS

RESEARCH IN THEORIES OF DISCRETE STRUCTURES
Task 1100-10-5116/56-159

Origin: NBS
Sponsor: Office of Naval Research
Manager: O. Taussky-Todd
Full task description: July-Sept 1955 issue, p. 1

Status: CONTINUED. O. Taussky continued her investigations concerning the higher commutators of a matrix A and its transposed and conjugate A*. For 3x3 matrices examples were constructed which show that the second, fourth, fifth, or sixth order commutator (A,A,...,A,A*) of A and A* can be the first one to vanish. If none of these vanishes, then no commutator of any order will vanish. Group matrices with vanishing fourth order commutators were also studied.

M. Newman and O. Taussky had proved earlier that a unimodular circulant of integers of the form AA' is also of the form CC' when C is again a circulant of integers. They now have shown that the weaker condition of positive definiteness does not suffice for circulants of order n \geq 8. A manuscript has been prepared.

M. Newman and O. Taussky are studying hermitian matrices and their decomposition into the form AA* where A may be rectangular.

Publications:
(6) Bounds and asymptotic behavior of the coefficients in the series log (e^x.e^y). K. Goldberg. In manuscript.
(12) Some free subgroups of the modular group. K. Goldberg and M. Newman. In manuscript.

RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS
Task 1101-10-1104/55-55

Origin: NBS
Manager: J. Todd, P. Davis
Full task description: July-Sept 1954 issue, p. 1

Status: CONTINUED. H. A. Antosiewicz has continued his work on the survey of conditions for the stability of solutions of ordinary differential equations which are based on Lyapunov's second method. Particular emphasis has been paid to those conditions that guarantee stability "in the large." Among them and related to them are criteria for the ultimate boundedness of every solution. The concept of ultimate boundedness is important in many cases of practical interest: For non-linear differential equations of the second order it has been investigated previously by G. E. Reuter and for more general equations by T. Yoshizawa. The latter's method of attack is closely related to Lyapunov's method.

P. Davis and Ky Fan have completed the present phase of their study on inequality and approximation in function spaces. It will probably be resumed when Professor Ky Fan returns to the Bureau in the summer.

J. Todd has continued his survey of various topics in the theory of approximation that are applicable in numerical analysis. Arising out of this, J. Todd has planned a new tabulation of the Cauer parameters, with an independent variable different from that used by Glowatski. These parameters arise in the design of electrical circuits and are expressed in terms of elliptic functions, the modular parameter of which depends, in the case of filters for example, on the permissible width of the frequency band in the pass-and-stop interval.

K. Goldberg continued his study of iterated convolutions.

Publications:
(5) Some Monte Carlo experiments for computing multiple integrals. P. Davis and P. Rabinowitz. To appear in Mathematical Tables and Other Aids to Computation.
(10) Note on bounds for determinants. E. V. Haynsworth. In manuscript.

RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO
NUMERICAL ANALYSIS
Task 1101-10-5116/55-56

Origin: NBS
Sponsor: Office of Naval Research
Managers: J. Todd, M. Newman
Full task description: July-Sept 1954 issue, p. 5

Status: CONTINUED. Some experiments in inverting matrices and
solving linear systems (using the floating point routines for these
purposes, described previously) were undertaken by M. Newman and I. Stegun.
It was found that even for matrices of orders as high as 60, round-off
error remained negligible. Comparing these results with those obtained
from fixed point routines, the conclusion seems to be that both time-wise
and accuracy-wise floating point routines are to be preferred. A more or
less detailed description and evaluation of various codes for matrix
operations is being prepared.

Some new floating point routines for computing such functions as
\( \log x \), \( e^x \), have been prepared by M. Newman.
A. J. Hoffman has completed an expository article (see publication
(22) below) on linear programming, summarizing the highlights of the theory,
computing procedures and applications of the subject.

Ky Fan, I. Glicksberg (University of Notre Dame), and A. J. Hoffman,
have completed a manuscript (publication (23) below) on systems of inequalities
involving convex functions. Questions relating to the consistency, independence,
and so forth, of a system of inequalities \( f_i(x) < 0 \), where the \( f_i \) are convex
functions defined on a convex set in a real linear space, are shown to be
resolvable almost as simply as the corresponding questions for systems of
linear inequalities that they generalize.

A. J. Hoffman has shown (in publication (24)) that a simple
combinatorial lemma yields a generalization of a well-known theorem of König
on systems "representing" two partitions of a given set. The lemma states
that if the incidence matrix of points vs. subsets for a given set \( R \) and
family of subsets \( \{S_i,...,S_n\} \) has the unimodular property that every square
sub-matrix is singular or unimodular, and \( 0 < \alpha < 1 \), then there exists a
set \( C \subseteq R \) such that \( |C \cap S_i - \alpha J_i| < 1 \). (\( A \) denotes the cardinality of
the set \( A \).)

Publications:
J. 8, 29-31 (1956).
(2) Generalizations of identities for coefficients of certain modular forms.
(3) Compactification of completely regular spaces. Ky Fan and F. Wagner
(University of Notre Dame). In manuscript.
(4) On dominant eigenvalues of positive matrices, T. Kato. In manuscript.
(6) On generating functions of the Jacobi polynomials. P. Henrici. Pac. J.
(7) Error bounds for eigenvalues of symmetric integral equations. H. Wielandt.
To appear in the Proceedings of the American Mathematical Society Sixth
Symposium on Applied Mathematics, held at Santa Monica, California, 1953.
Status of Projects


(13) Notes on some scheduling programs. A. J. Hoffman. In manuscript.

(14) On block relaxation. L. S. Joel. In manuscript.


(16) The lowest frequency of a free square plate. H. Fujita (University of Tokyo), T. Kato, Y. Nakata (University of Tokyo), and M. Newman. In manuscript.


(23) Systems of inequalities involving convex functions. Ky Fan (University Notre Dame), I. Glicksberg (RAND Corporation), and A. J. Hoffman. In manuscript.


ANALYTIC STUDY OF WAR GAMES
Task 1101-10-5116/55-83

Origin and Sponsor: Armament Branch, ARDC, USAF
Manager: H. A. Antosiewicz
Full task description: Oct-Dec 1954 issue, p. 7
Status: INACTIVE.

STUDY OF DIFFERENTIAL EQUATIONS FOR NERVE EXCITATION
Task 1101-10-5116/56-148

Origin and Sponsor: National Institutes of Health
Manager: H. A. Antosiewicz
Full task description: July-Sept 1955 issue, p. 7
Authorized 9/30/55
Status of Projects

Status: CONTINUED. A new method has been adopted for the determination of the values of the parameter K for which the solutions of the basic system of differential equations have a prescribed behavior. The previously used method was based on an approximation to the positive eigenvalue, and its corresponding eigenvector, of the $5 \times 5$ matrix which represents the linear part of the system of differential equations. Now, this positive eigenvalue and its eigenvector are computed for each value of the parameter K, and the initial conditions determining the particular solution are then chosen for the eigenvector. The change in the computation was felt necessary because the bounds for the derived values of K found by the old procedure were so close that further approximations might have yielded spurious results.

About 30 cases, both for temperatures 6.3°C and 18.5°C, were run during this quarter and were submitted to the sponsor.
2. **MATHEMATICAL TABLES AND PROGRAMMING RESEARCH**

**TABLES OF E₁(z), (z=x+iy)**

**Task 1102-40-1110/43-3**

Manager: I. Stegun  
Authorized 7/1/47

Full task description: Apr-June 1949 issue, p. 41  
Status: CONTINUED. The introduction to the tables has been prepared and checking is in progress.

**TABLES OF COULOMB WAVE FUNCTIONS**

**Task 1102-40-1110/47-2**

Origin: NBS  
Manager: M. Abramowitz  
Authorized 7/1/47

Full task description: Apr-June 1949 issue, p. 45  
Status: CONTINUED. The code is being revised to carry out computations of the functions for a range of values of ρ corresponding to given η and L.

**TABLES OF POWER POINTS OF ANALYSIS OF VARIANCE TESTS**

**Task 1102-40-1110/51-8**

Origin: Section 11.3, NBS  
Manager: S. Peavy  
Authorized 3/26/51

Full task description: Apr-June 1951 issue, p. 49  
Status: INACTIVE. For status to date, see Oct-Dec 1955 issue, p. 8.

**REVISION OF MATHEMATICAL TABLES**

**Task 1102-40-1110/52-7**

Origin: NBS  
Managers: W. F. Cahill, I. Stegun  
Authorized 8/10/51

Full task description: July-Sept 1951 issue, p. 41  
Status: CONTINUED. Revision of "Tables of natural logarithms," vol. IV, Mathematical Table MT12 (1941), for reissue in the Applied Mathematics Series was completed, and the manuscript is ready for submittal for publication.
Status of Projects

TABLE OF ARCSIN FOR COMPLEX ARGUMENTS
Task 1102-40-1110/52-14

Origin: NBS
Manager: B. Urban
Full task description: July-Sept 1951 issue, p. 41

Status: TERMINATED. It was decided to discontinue preparation of the table for publication because a more comprehensive table of the function was recently published elsewhere.

TABLE OF THE MODIFIED AIRY INTEGRAL
Task 1102-40-1110/52-23

Origin: NBS
Manager: I. Stegun
Full task description: July-Sept 1951 issue, p. 42

Status: CONTINUED. Checking of the completed manuscript is in progress.

TABLE OF ERROR FUNCTION FOR COMPLEX ARGUMENTS
Task 1102-40-1110/52-25

Origin: NBS
Manager: W. Hall
Full task description: July-Sept 1951 issue, p. 42

Status: INACTIVE. For status to date, see Oct-Dec 1954 issue, p. 11.

SPHEROIDAL WAVE FUNCTIONS
Task 1102-40-1110/52-37

Origin: NBS
Manager: D. Liepman
Full task description: Oct-Dec 1951 issue, p. 38

Status: INACTIVE.

SIEVERT'S INTEGRAL
Task 1102-40-1110/52-57

Origin: NBS
Managers: M. Paulsen, P. O'Hara
Full task description: Jan-Mar 1952 issue, p. 46

Status: CONTINUED. Checking of the tabular values and preparation of the introductory material continued.
Status of Projects

L-SHELL CONVERSION COEFFICIENTS
Task 1102-40-1110/53-52

Origin: Oak Ridge National Laboratory
Manager: W. Hall
Full task description: Apr–June 1953 issue, p. 45

Status: CONTINUED. Computations for the L_{III} shell were completed for \( z = 65 \) for all values of \( k \); for \( z = 95 \), \( k = .05 \), 0.1; and for the L_{I} shell for \( z = 55 \), \( k = .05 \).

AUTOMATIC CODING
Task 3711-60-0009/55-65

Origin: NBS
Manager: J. Wegstein
Full task description: July–Sept 1954 issue, p. 11

Status: CONTINUED. A new Base code, BASE 11, has been completed. It is intended to be used specifically for small problems involving integrals. In it the 1-, 2- and A-orders of Base 00 are replaced by two-word "integrate" orders completely specifying an integration of the form

\[
\int_a^b f(x) \, dx
\]

By the use of the three integration orders general expressions of the form \( \int \int \int f(x,y,z) \, dx \, dy \, dz \) can be coded using only two words to specify each integration and the coding necessary to compute the various functions. The integration rule is Gaussian quadrature, and 2-, 4-, 8-, and 16-point rules for any interval may be specified.

Base 11 should be useful in coding small problems quickly where the behavior of the functions involved is well known and only one integration is involved or separation of variables cannot be effected. It may also be used for larger problems provided the necessary numerical analysis is carried out.

In addition to the integration routines, Base 11 also contains all of the service routines and subroutines of Base 01 (see Oct–Dec 1955 issue, p. 10.)

Work was begun on the BUIC system for SEAC. It is a generating routine which accepts problems stated in a notation written directly from the flow diagram of the problem. Algebraic expressions are accepted directly by the computer in the same form that they can be understood by any mathematician. Complete logical details have been worked out for the algebra encoder portion of this system. The feasibility of building a computer which will operate at high speed directly on algebraic and flow chart symbols is also being studied.

MATHEMATICAL SUBROUTINES
Task 3711-60-0009/56-160

Origin: NBS
Manager: Staff
Full task description: July–Sept 1955 issue, p. 13

Status: CONTINUED. The development of a base code for matrices which may be used in problems requiring several types of operations on small
matrices was started. The code will be similar to the Base 00 and will use most of the Base 00 operations. It will contain subroutines to add and multiply matrices, to compute the value of determinants, to orthonormalize a set of vectors, and to compute the inverse of a given matrix. The elements of the matrices will be expressed in floating binary point form. During this quarter, the addition, multiplication, and determinant evaluation subroutines were written and code checking of these routines was started.
3. PROBABILITY AND MATHEMATICAL STATISTICS

BIBLIOGRAPHY AND GUIDE TO STATISTICAL LITERATURE
Task 1103-10-1107/49-1a

Origin: NBS
Manager: L. S. Deming
Full task description: Apr-June 1949 issue, p. 75
Status: CONTINUED. For a description of the continuing activity on this task, see the Jan-Mar 1954 issue, p. 49.

MANUAL ON FITTING STRAIGHT LINES
Task 1103-10-1107/50-2

Origin: NBS
Manager: F. S. Acton
Full task description: Jan-Mar 1950 issue, p. 42
Status: COMPLETED. The manual on the fitting of straight lines has been completed and is being edited for publication by a commercial house. Some material from it is being abstracted for use by the ASTM in their handbook on the "Presentation of Data." The straight line manual is divided into ten chapters whose titles are:

Chapter I - General introduction
II - X - Without error - Classical ideas
III - Several values of y for each x
IV - Bivariate normal population
V - Both variates in error
VI - Several lines - The analysis of variance
VII - Orthogonal polynomials - Curvature
VIII - Transformations
IX - Rejection of data
X - Cumulative data

TABLES TO FACILITATE DRAWING RANDOM SAMPLES
Task 1103-10-1107/51-1

Origin: NBS
Managers: C. Eisenhart, L. S. Deming
Full task description: July-Sept 1950 issue, p. 57
Status: INACTIVE. For status to date, see July-Sept 1952 issue, p. 64.
Status of Projects

MISCELLANEOUS STUDIES IN PROBABILITY AND STATISTICS
Task 1103-10-1107/51-2

Origin: NBS
Manager: C. Eisenhart
Full task description: July-Sept 1950 issue, p. 58

Status: CONTINUED. For a description of the continuing activity on this task, see the Oct-Dec issue, p. 12.

Publications:
(3) A comparison between the mean successive differences and the root mean square successive difference. S. Geisser. Withdrawn from publication.
(4) Inequalities for probabilities associated with the multivariate normal distribution. I. R. Savage. Withdrawn from publication.

STUDIES IN THE MATHEMATICS OF EXPERIMENT DESIGN
Task 1103-10-1107/53-1

Origin: NBS
Manager: W. S. Connor
Full task description: Oct-Dec 1952 issue, p. 60

Status: CONTINUED. R. C. Burton has written a note on "Some existence theorems for dualized designs."

Publications:
(2) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.
(3) Exact tests of significance for combining inter- and intra-block information. M. Zelen. Submitted to a technical journal.
(5) Fractional factorial experiment designs for factors at two levels. To appear as NBS Applied Mathematics Series 48.
Status of Projects

RESEARCH ON MATHEMATICAL ASPECTS OF ORDER STATISTICS METHODS
Task 1103-10-1107/55-110

Origin: NBS
Manager: J. Lieblein
Full task description: Jan-Mar 1955 issue, p. 31

Status: CONTINUED. J. Lieblein consulted with E. L. Brancato and W. F. Gauster of the Naval Research Laboratory on the application of extreme-value theory to data on breakdown voltage of transformer oil. Dr. Lieblein also corresponded, among others, with N. T. Uzgoren (University of Istanbul, Turkey) on theoretical aspects of the asymptotic development of the distribution of extreme values, and with E. Gassner (Darmstadt, Germany) on the fit of a formula used in fatigue-life testing of ball bearings.

The final report (see Jan-Mar 1955 issue, p. 33) to Subcommittee 7 (Load Ratings) of the American Standards Association Committee B-3 (Ball and Roller Bearings), on "Statistical investigations of the fatigue life of deep groove ball bearings" has been developed into an article for submittal to a technical journal.

Publication:
(1) Application of extreme value theory to cobbles and boulders in gravel deposits. W. C. Krumbein (Northwestern University) and J. Lieblein. Submitted to a technical journal.

STUDY OF NON-PARAMETRIC STATISTICAL TECHNIQUES
Task 1103-10-1107/56-170

Origin: NBS
Manager: Joan R. Rosenblatt
Full task description: Oct-Dec 1955 issue, p. 14

Status: CONTINUED. A paper is being prepared on the power of some rank order two-sample tests. A talk on the efficiency of statistical tests was given at a Statistical Engineering Laboratory Seminar on February 17. Work was continued on the distribution of Burrow's statistic.

Publications:
(1) Easily used simultaneous confidence limits for a line. W. S. Connor. Submitted to a technical journal.
Status of Projects

MEASUREMENT OF RELIABILITY
Task 1103-10-1130/56-182

Origin: NBS
Manager: M. Zelen

Authorized: 3/23/56

Objective: To conduct research on the mathematical and statistical aspects of the definition, measurement, and specification of the reliability of components and assemblies, with particular attention to the evaluation of the reliability of electronic components and systems.

Background: The improvement of the reliability of electronic equipment, civilian as well as military, is one of the major problems of science and technology today. It is highly desirable that electronic computers and communications equipment operate with satisfactory reliability over relatively long periods of continuous or intermittent use. On the other hand, electronic systems of guided missiles, for example, are required to withstand a long "shelf-life" yet perform with high reliability during their very brief period of use. While it is widely recognized that reliability is primarily a probability problem, and that the measurement of reliability is largely a statistical problem, only a beginning has been made in applying recent developments in statistical inference, experiment design, and statistical analysis, to the definition and measurement of the reliability of complex assemblies.

Status: NEW. Examples of the literature on measurement and prediction of reliability are being collected and reviewed.

Work is being done on methods for obtaining confidence limits for the product of binomial parameters.
RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS
Task 1104-10-1115/55-57

Status: CONTINUED. New methods have been developed by P. Henrici to speed up the convergence of the Quotient-Difference Algorithm and to apply it to the numerical determination of the residues of a meromorphic function. Also some applications were made of I. N. Vekva's theory of elliptic differential equations with analytic coefficients. Several representations for the complex Riemann function of the equation

\[ \Delta u + \frac{\nu}{y} \frac{\partial u}{\partial y} + k^2 u = 0, \]

have been obtained.

As a continuation of previous work on addition theorems P. Henrici has obtained several new addition theorems for Lommel functions. These are of importance in the solution of the inhomogeneous wave equation.

Publications:
(2) Entropy changes in rarefaction waves. R. F. Dressler. Submitted to a technical journal.
(7) The quotient-difference algorithm. P. Henrici. In manuscript.

RESEARCH IN ELECTROMAGNETIC THEORY
Task 1104-10-5160/54-47

Status: INACTIVE.
Status of Projects

RESEARCH IN MATHEMATICAL ELASTICITY
Task 1104-10-5160/55-85

Origin: NBS
Sponsor: Office of Scientific Research, ARDC, USAF
Manager: R. F. Dressler
Full task description: Oct-Dec 1954 issue, p. 30

Status: CONTINUED. The second phase of the corrugated diaphragm project is being continued,—to analyze a sequence of diaphragms with a fixed shape for a range of different thicknesses in order to determine the relative importance of bending and stretching effects. The problem originally solved by R. F. Dressler and W. Cahill was for a thickness $h = .007$ inches. Now the case $3h$ has been completely solved also and exhibits the following interesting property: For average thicknesses, all stresses causing stretching vary with the same frequency as the corrugation profile shape, whereas all bending stresses vary with a double frequency. However, for the thick diaphragm the present results indicate that the double frequency behavior almost disappears for all bending stresses. The next case, now being analyzed, corresponds to $h/3$. For this problem all four homogeneous solutions were computed, but the general solution is not yet completed.

On the vibrating triangular wing project, I. Rhodes and U. Hochstrasser satisfactorily rectified the difficulty in the code for obtaining higher eigenvalues and eigenvectors for the basic $78 \times 78$ asymmetric matrices. On small test matrices the second eigenvalues were obtained with high accuracy; this code is to be applied to the large matrices describing the wing problem.

J. L. Synge worked on a geometrical approach to problems of forced vibrations in elasticity, the solution appearing as the intersection of two orthogonal linear subspaces in a suitable function space. This approach led to methods of approximate solution. A paper on this work is to be presented at the Eighth Symposium on Applied Mathematics, Chicago, April 12-13.

J. L. Synge has applied tensor methods to the study of the general theory of linear elastic waves in completely anisotropic media, developing a theory of Rayleigh surface waves in such media. A report on this investigation was prepared.

J. L. Synge and W. Cahill engaged on an approximate numerical solution on SEAC of the elastic torsion problem for the hollow square. The solution uses the Prager-Synge hypercircle method, which gives upper and lower bounds for the torsional rigidity. Final calculations on the SEAC for this problem are in progress.

Publications:
(2) Stationary principles for forced vibrations in elasticity and electromagnetism. J. L. Synge. Submitted to a technical journal.
(3) Elastic waves in anisotropic media. J. L. Synge. In manuscript.
Status of Projects
FOURIER TRANSFORMS OF PROBABILITY DISTRIBUTION FUNCTIONS
Task 1104-10-5160/56-154

Origin: NBS
Sponsor: Office of Naval Research
Managers: F. Oberhettinger, J. Lieblein
Full task description: July-Sept 1955 issue, p. 20

Status: CONTINUED. Further examples have been added to the
collection of Fourier transforms of distribution functions. This completes
the present compilation, which contains some previously underived results.
The whole material is in systematic form ready for book publication when
the accompanying text is written.

RESEARCH IN FLUID DYNAMICS OF TWO-PHASE FLOWS
Task 1104-10-5160/56-155

Origin: Office of Naval Research
Sponsor: Office of Naval Research
Manager: R. F. Dressler
Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. Relations between the states on both sides of
an interface separating two phases of a moving fluid have been determined
for the cases in which the phase transition is brought about by heat
removal and/or cold liquid addition at the interface. If the specific
volume of the liquid state is neglected in comparison with the specific
volume of the vapor state and the enthalpy of the liquid state is given
as a linear function of the temperature alone, then an explicit solution
has been found for the liquid state variables in terms of the other parameters.
For more accurate results, a rapidly converging iterative scheme has been
developed which utilizes directly thermodynamic tables of the vapor and
liquid. Some calculations have been made for the specific case of a steam-
water interface. For a stationary interface and fixed thermodynamic state
of the vapor, upper and lower bounds for heat removal or mass addition
rates have been found as a function of the incoming steam velocity. Conversely,
for given heat removal or mass addition, bounds have been obtained for the
steam velocity. A paper on this first aspect of the investigation has been
prepared.

Publication:
In manuscript.

RESEARCH IN MATHEMATICAL GEOPHYSICS
Task 1104-10-5160/56-156

Origin: The American University
Sponsor: Office of Naval Research
Manager: R. Stoneley
Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. The investigation of the variation of amplitude
with depth for Rayleigh waves in a continent with a double surface layer
has been completed by R. Stoneley and U. Hochstrasser. The results show
that a nodal point for the amplitude may exist in either of the two surface
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layers depending upon the relative sizes of the various parameters. This work was presented at the meeting of the Seismological Society of America, Reno, Nevada, March 30–31.

A paper dealing with the hydrodynamical aspects of turbidity currents in oceans was also completed by R. Stoneley.

The problem of the propagation of Rayleigh waves across an ocean floor in which there are two rocky layers has been programmed by U. Hochstrasser for computation by the SEAC.

Four lectures by R. Stoneley presented at an NBS seminar on the general theory of elastic surface waves have been written up as notes by P. Henrici. This will also be incorporated in a Monograph on elastic waves which is now in preparation.

Publications:
(3) Lectures on elastic surface waves. R. Stoneley. In manuscript.

RESEARCH IN RADIATION THEORY
Task 1104-10-5160/56-175

Origin: NBS
Authorized 12/28/55
Sponsor: Office of Naval Research
Manager: F. Oberhettinger
Full task description: Oct-Dec 1955 issue, p. 18

Status: CONTINUED. Investigations concerning the asymptotic behavior of certain integrals describing the far zone field of electromagnetic waves diffracted by a wedge are continuing. The case of an incident plane wave field (see J. Math. Phys. 34, 1956) is being extended to take care of an incident cylindrical and spherical wave field. This involves reduction of integrals of the form

$$I(\theta, \alpha) = -\frac{1}{2\alpha} \sin \left( \frac{\pi \theta}{\alpha} \right) \int_0^\infty \frac{H(x)}{\cosh(\pi x/\alpha) - \cos(\pi \theta/\alpha)} \, dx$$

with

$$H(x) = \begin{cases} H_0^{(2)}[k(\rho^2 + \rho^{12} + 2\rho \rho' \cosh x)^{1/2}] \\ \exp(-ik[\rho^2 + \rho^{12} + (z-z')^2 + 2\rho \rho' \cosh x]^{1/2})/\rho^2 + \rho^{12} + (z-z')^2 + 2\rho \rho' \cosh x]^{1/2} \end{cases}$$

into an asymptotic series for large \( \rho \).
5. MATHEMATICAL AND COMPUTATIONAL SERVICES

1102-40-5126/50-13 RAY TRACING
Origin and Sponsor: NBS, Section 2.2
Manager: E. Haynsworth, P. Walsh
Full task description: Jan-Mar 1950 issue, p. 33
Status: Continued. It was found necessary to compute the inverse of a given matrix \((n \leq 28)\) which was stored in fixed binary point form. A code was written in two parts: (1) To read in the matrix and convert it to floating binary point form. A previously written code for computation of the inverse in floating binary point form was then used. (2) To convert the inverse of the matrix from floating binary point form, and to transfer the matrix to wire by rows. The two sections of the code are being checked out.

1102-40-5126/51-37 MOLECULAR STRUCTURE, III
Origin and Sponsor: Naval Research Laboratory, USN
Manager: P. O'Hara
Full task description: July-Sept 1951 issue, p. 50
Status: Continued. Additional analyses were performed to determine the structures of the spurite and dimethoxybenzophenone crystals.

1102-40-5126/52-44 CALCULATIONS FOR d SPACINGS
Origin and Sponsor: NBS, Division 9
Full task description: Oct-Dec 1951 issue, p. 47
Manager: R. Zucker
Status: Continued. Calculations for \(d\)-spacings were performed for 3 tetragonal, 9 hexagonal and 20 orthorhombic crystals. Also determination of unit cell constants was carried out by least squares fitting to measured \(d\)-spacings for 7 tetragonal, 6 hexagonal, and 23 orthorhombic crystals.

1102-40-5126/53-27 COMPUTATION OF THERMODYNAMIC FUNCTIONS
Origin and Sponsor: NBS, Section 3.2
Manager: E. Marden
Full task description: Jan-Mar 1953 issue, p. 57
Status: Continued. Thermodynamic functions were re-computed for zinc \((Z,T)\), making use of revised input constants. Under another code thermodynamic functions were computed for trans-difluorodichloroethylene.

1102-40-5126/53-51 RADIATION DIFFUSION
Origin: NBS, Section 4.8
Sponsor: Atomic Energy Commission
Manager: J. Doggett (4.8)
Full task description: Apr-June 1953 issue, p. 57 (Neutron Diffusion III)
Status: Continued. The data obtained from the Mott formula code for the elastic scattering of electrons and positrons by nuclei have been checked by interpolation schemes and reruns. A manuscript on the results has been
submitted to a technical journal.
The basic codes for the generation of collision density patterns of gamma radiation by Monte Carlo methods have been revised. Preliminary runs indicate an increase by a factor of two in the operational efficiency of the code.

1102-40-5126/54-13 AWARD OF PROCUREMENT CONTRACTS BY LINEAR PROGRAMMING
Origin and Sponsor: New York Quartermaster Procurement Agency
Manager: H. Bremer
Full task description: Oct-Dec 1953 issue, p. 43
Status: Continued. Analysis of contract award problems continued to be processed on SEAC as they were submitted by the sponsor. During this quarter, the awards for approximately 15 contracts were determined.

3711-60-0009/54-17 DEPOLYMERIZATION
Origin: NBS, Section 7.6
Manager: U. Hochstrasser
Full task description: Oct-Dec 1953 issue, p. 44
Status: Continued. Some additional cases were run with new values of the parameters $\sigma$ and $\varepsilon$ as needed in further investigations under way by the originator.

3711-60-0009/54-22 ENERGY DISTRIBUTIONS ON OPTICAL IMAGE
Origin: NBS, Section 2.2
Manager: L. S. Joel
Full task description: Jan-Mar 1954 issue, p. 43
Status: Continued. The new code was verified as correct for $W = \arctan(y/x)$,

\[ W = 9x(x^2 + y^2). \]

3711-60-0009/54-30 SPECTRUM ANALYSIS
Origin: NBS, Division 4
Manager: S. Prusch
Full task description: Jan-Mar 1954 issue, p. 46
Status: Continued. Searching for pairs of lines for approximately 14 common differences was carried out for Ruthenium I.

3711-60-0009/54-38 COMPRESSIBILITY FACTORS OF DRY AIR
Origin: NBS, Section 3.2
Manager: M. Paulsen
Full task description: Jan-Mar 1954 issue, p. 48
Status: Inactive. For status to date, see Apr-June 1955 issue, p. 12.

1102-40-5126/55-39 MOLECULAR VIBRATIONS
Origin and Sponsor: NBS, Section 3.2
Manager: K. Goldberg
Full task description: July-Sept 1954 issue, p. 16
Status: Inactive.

1102-40-5126/54-43 CHARACTERISTICS OF CONDUCTING RESISTORS
Origin and Sponsor: NBS, Section 1.6
Manager: B. G. Urban
Full task description: Apr-June 1954 issue, p. 40
Status: Inactive. For status to date, see Apr-June 1955 issue, p. 12.
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3711-60-0009/55-53 ELECTRONIC FUNCTIONS
Origin: NBS, Section 4,5
Manager: W. G. Hall
Full task description: Apr–June 1955 issue, p. 12
Status: Continued. The tabular material was typed, and the final readying of the manuscript for publication was almost completed.

1102-40-5126/55-55 ELECTROMAGNETIC RADIATION FROM LIGHTNING
Origin and Sponsor: NBS, Section 82.1
Manager: B. G. Urban
Full task description: Jan–Mar 1955 issue, p. 17
Status: Inactive. For status to date, see Jan–Mar 1955 issue, p. 17.

1102-40-5126/55-61 ELASTIC CROSS SECTION FOR NEUTRON SCATTERING
Origin and Sponsor: Naval Research Laboratory
Manager: I. Stegun
Full task description: Oct–Dec 1954 issue, p. 18
Status: Inactive. For status to date, see Apr–June 1955 issue, p. 13.

3711-60-0009/55-66 RECONSTITUTION OF MONOCHROMATIC LIGHT INTENSITIES
Origin: NBS, Division 30
Manager: H. Bremer
Full task description: July–Sept 1954 issue, p. 18

3711-60-0009/55-68 CRYSTAL STRUCTURE CALCULATIONS
Origin: NBS, Division 9
Manager: R. Prosen
Full task description: Jan–Mar 1955 issue, p. 18
Status: Continued. A general program applicable to all crystallographic space groups is being written that will calculate least squares refinements for atomic positions as well as individual anisotropic temperature factor parameters for each atom. Code-checking of the general structure factor routine is progressing satisfactorily. The code for the general Fourier routine to calculate three-dimensional electron density maps has been punched and is ready for checking.

1102-40-5126/55-74 LIQUID–VAPOR TRANSITION, II
Origin and Sponsor: Naval Medical Research Institute
Manager: S. Prusch
Full task description: Jan–Mar 1955 issue, p. 19
Status: Inactive.

3711-60-0009/55-75 PARAMETER OF THE DISPERSION EQUATION FOR OPTICAL GLASS
Origin: NBS, Section 2,2
Manager: R. Zucker
Full task description: Jan–Mar 1955 issue, p. 20
Status: Continued. For a given set of observed wavelength $\lambda$, and index of refraction $n$, the constant of dispersion $k_i$ was determined by the method of least squares, using the original code. A new code was written and checked to set up a table of the computed values of $n_c$:

$$n_c = 1 + \sum_{i=1}^{5} \frac{k_i}{\lambda^2 - \lambda_i^2}$$

The table of $n_c$ was prepared for $\lambda = .5^4(.02)2(.2)20(.1)^{40}$ for given values of $\lambda_i^2$ and $k_i$. 
COMBINING TESTS FOR SIGNIFICANCE
Origin: NBS, Section 11.3
Manager: L. S. Joel
Full task description: Oct-Dec 1954 issue, p. 23
Status: Continued. The bulk of the results for the table have been transmitted to the sponsor. It remains to compute and check scattered values.

THERMOMETER CALIBRATIONS
Origin: NBS, Section 3.1
Manager: S. Prusch
Full task description: Jan-Mar 1955 issue, p. 20
Status: Continued. Calibration tables were run on approximately 49 thermometers under test.

STRESSES IN A WALL FOUNDATION
Origin and Sponsor: NBS, Section 10.1
Managers: E. Marden, G. Hawkins
Full task description: Jan-Mar 1955 issue, p. 22
Status: Inactive.

MISSOURI RIVER PROBLEM
Origin and Sponsor: Missouri River Division, Corps of Engineers, U.S. Army
Manager: H. Bremer
Full task description: Jan-Mar 1955 issue, p. 26
Status: Continued. New data from the sponsor was processed on UNIVAC using codes already set up.

AERONOMIC TIDAL WINDS OF THERMAL ORIGIN
Origin and Sponsor: NBS, Section 82.1
Managers: B. G. Urban, H. H. Howe (82.1)
Full task description: Jan-Mar 1955 issue, p. 26

REACTOR DESIGN
Origin: Westinghouse Atomic Power Division
Sponsor: Atomic Energy Commission
Manager: U. Hochstrasser
Full task description: Jan-Mar 1955 issue, p. 28
Status: Continued. Some changes in the code were made in order to be able to iterate on the equations for high and low energy level flux separately. A change in the computation of the eigenvalues was prepared. Several additional runs with the original code were made in order to complete the study of the best choice of an over-relaxation factor.

ATTENUATION OF PRESSURE PULSES OF FINITE AMPLITUDE
Origin: NBS, Section 3.2
Sponsor: Bureau of Aeronautics, U. S. Navy
Manager: M. Paulsen
Full task description: Apr-June 1955 issue, p. 18
Status: Inactive. For status to date, see July-Sept 1955 issue, p. 30.
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1102-40-5126/55-118  THERMOMETER CALIBRATION, II
Origin and Sponsor: NBS, Section 3.1
Manager: B. G. Urban
Full task description: Apr–June 1955 issue, p. 18
Status: Continued. An additional code to compute certain constants and differences formerly computed by hand was completed and checked out.
Tables for eight thermometers were computed and transmitted to sponsor.
A supplementary code to edit finished results is being written.

1102-40-5126/55-121  ELECTRON PENETRATION
Origin: NBS, Section 4.8
Sponsor: Atomic Energy Commission
Manager: S. Peavy
Full task description: Apr–June 1955 issue, p. 19
Status: Continued. Preparation of the code continued.

1102-40-5126/55-122  SOLUTION OF NORMAL EQUATIONS
Origin: Advisory Committee on Weather Control
Sponsor: U. S. Weather Bureau
Manager: M. Newman
Full task description: Apr–June 1955 issue, p. 20
Status: Inactive.

1102-40-5126/55-123  TEMPERATURE DISTRIBUTION
Origin: NBS, Section 6.4
Sponsor: NBS, Section 6.4
Manager: W. G. Hall
Full task description: Apr–June 1955 issue, p. 19

1102-40-5126/55-124  EVALUATION OF INTEGRALS RELATED TO GAS FLOW
Origin: NBS, Section 3.2
Sponsor: Bureau of Aeronautics, U. S. Navy
Manager: J. Cooper
Full task description: Apr–June 1955 issue, p. 20
Status: Reactivated. The project was reopened to compute values of the integrals $R_1$ and $R_2$ for new parameters. In addition, the code was modified so that the times taken to fill containers could be computed directly. This involved computing the following quantities for each value of $a$, instead of $R_1$ and $R_2$.

$$t_1 = a \sqrt{3} R_1 + t_c$$
$$t_2 = a R_2 + t_c$$

where
$$t_c = 14.022 [(1-x_c)^{-1/7} - 1]$$

and
$$x_c = a \left[ \frac{0.528(1+.005a)}{1+.528a} - 0.005 \right]$$

Calculations were made for 12 values of $a$ ranging from 0.1130 to 0.9040 and for $\beta = 0.533(.05), .033, .963, .983$. 


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1102-40-5126/55-126 AERODYNAMIC HEATING
Origin and Sponsor: Diamond Ordnance Fuze Laboratory, Dept. of the Army
Managers: B. Walter, R. Capuano
Full task description: July-Sept 1955 issue, p. 31
Status: Continued. T_w was calculated with the following modifications:

\[ \frac{Bh}{c} \Delta T, \]

increased by 20% and \( T_{aw} \) increased 8°F for each of the four missile trajectories. The corresponding variations of \( T_w \) and of the \( T_w \) intersections were calculated and compared with the modifications described in the Oct-Dec 1955 issue, p. 24.

A table of \( W \) as a function of \( L, M, \) and \( \Delta S \) was calculated for each of the four trajectories from the equation,

\[ \Delta W = \frac{M - W_1}{1 + \frac{1}{L\Delta S} + \frac{L}{2}} \]

where \( M = 19.62 \cos \left( \frac{\theta_1 + \theta_2}{2} \right), \)

\[ L = (C_{D1} + C_{D2})(\rho_1 + \rho_2)1.186 \times 10^{-3}, \]

\[ \Delta S = V\Delta t, \]

and tables of \( \theta, \rho, C_D \) were given. Based on the computed values of \( W \), the original velocity was then checked against the velocity obtained by the relation,

\[ \Delta V = \frac{V_1}{2} \left( \frac{\Delta W}{W_1} \left[ 1 - \frac{1}{4} \frac{\Delta W}{W_1} + \frac{1}{8} \left( \frac{\Delta W}{W_1} \right)^2 - \frac{5}{64} \left( \frac{\Delta W}{W_1} \right)^3 + \ldots \right] \right), \]

where \( W_1 = V_1^2. \)

Then \( L \) was increased by 20%, which is equivalent to increasing the ambient density by 20%, and the change in \( V \) was determined in accordance with the above equations.

The values of \( T_w \) as a function of time were calculated for the modified density and velocity conditions in accordance with the procedure previously outlined (Oct-Dec 1955 issue) for two of the ranges. The intersections of the two strip temperatures were then compared with those obtained for the unmodified conditions.

1102-40-5126/55-127 VIBRATIONS OF CIRCULAR DISC
Origin and Sponsor: Evans Signal Laboratory
Manager: U. Hochstrasser
Full task description: July-Sept 1955 issue, p. 32
Status: Continued. A set of solutions for the equations described in the July-Sept 1955 issue has been obtained. The code has been changed in order to eliminate the singularities on the left-hand side of the mentioned equation.

3711-60-0009/56-131 RAY TRACING
Origin: NBS, Section 2.2
Manager: E. Marden
Full task description: July-Sept 1955 issue, p. 33
Status: Continued. Code checking is in progress.
1102-40-5126/56-133 COMPLEX EIGENVALUES
Origin: Moore School of Engineering
Sponsor: Office of Naval Research
Manager: I. Stegun
Full task description: July-Sept 1955 issue, p. 33.
Status: Continued. The largest eigenvalues for two matrices of order ten were obtained, together with the successive vectors.

1102-40-5126/56-134 TRANSMISSION-DELAY TIMES
Origin: NBS, Section 82.1
Sponsor: NBS, Section 82.1
Managers: B. G. Urban, H. H. Howe (82.1)
Full task description: July-Sept 1955 issue, p. 34
Status: Continued. The bulk of the tables have been computed.

1102-40-5126/56-136 CALCULATION OF WAVE FUNCTIONS BY HARTREE METHOD
Origin: Naval Research Laboratory
Sponsor: " " "
Manager: S. Peavy
Full task description: July-Sept 1955 issue, p. 34
Status: Continued. The new code was checked out, and the results were transmitted to the sponsor. The simplification of the equations reduced the SEAC time considerably. This made it possible to carry out the computation for certain cases to many iterations.

1102-40-5126/56-137 STABILITY OF SUPPORTED PLATES
Origin and Sponsor: National Advisory Committee on Aeronautics
Manager: R. Zucker
Full task description: July-Sept 1955 issue, p. 35
Status: Continued. Computations were continued for r=3 and r=2 for various combinations of k_c, k_s, and \beta. The calculations are now extended for negative values of k_c and k_s. As answers are obtained, they are submitted to the sponsor.

1102-40-5126/56-139 STUDY OF INTERNUCLEAR POTENTIAL FOR H_3
Origin and Sponsor: NBS, Section 3.2
Manager: E. Haynsworth
Full task description: July-Sept 1955 issue, p. 36

1102-40-5126/56-140 MULTIPLE CORRELATION ROUTINES
Origin and Sponsor: Agricultural Economics Division, Department of Agriculture
Managers: H. Bremer, M. Paulsen
Full task description: Oct-Dec 1955 issue, p. 26
Status: Continued. A program has been set up for the sponsor to do the computations on SEAC for least squares regression problems and the evaluation of correlation coefficients. This program consists of three basic routines.

For each regression problem the variables may or may not undergo any of the following transformations,--logarithm of original variables, the first difference of the variable or its logarithm. Using these transformed variables the moment matrix is then computed. This part of the program is designated as Routine I.
Routine II consists of existing codes for matrix inversion and
is used to compute the inverse of the moment matrix.
Routine III takes the inverse matrix and computes the
a) regression coefficient
b) standard errors of the partial regression coefficients
c) partial correlation coefficient
d) multiple correlation coefficient
e) standard errors of estimate and the constant for
the regression equation.

So far nine problems have been submitted by the sponsor and were
processed by the above program. Each problem took approximately 20 to
40 minutes depending upon the number of variables and number of observations.
It is hoped that this running time will be reduced by about one third when
the routines are better integrated. Also considerable time will be saved
if a matrix conversion code is written so that the entire problem can be
done in the internal memory,
It is planned that some additional routines will be written to
aid the sponsor in fitting systems of equations by the limited information
approach.

1102-40-5126/56-143 CHARGED PARTICLE TRAJECTORIES IN THE MAGNETIC FIELD
OF THE EARTH
Origin and Sponsor: Naval Research Laboratory
Manager: J. H. Wegstein
Full task description: Oct-Dec 1955 issue, p. 27
Status: Continued. The trajectories for 22 more sets of initial conditions
were computed with the NORC and were sent to the sponsor.

1102-40-5126/56-147 GROUND WAVE ATTENUATION
Origin and Sponsor: NBS, Section 82.1
Managers: B. G. Urban, H. H. Howe (82.1)
Full task description: Oct-Dec 1955 issue, p. 29
Status: Inactive. For status to date, see Oct-Dec 1955 issue, p. 30.

1102-10-5126/56-151 MULTIPLE SCATTERING IN CROSS SECTION MEASUREMENTS
Origin and Sponsor: Naval Research Laboratory
Manager: I. Rhodes
Full task description: Oct-Dec 1955 issue, p. 30
Status: Continued. Of the 16 sets of parameters, assigned computations on
four have been completed. Computing time takes from 25 to 40 minutes,
depending on the number of trials required.

1102-40-5126/56-152 COST ACCOUNTING OPERATIONS FOR HIGH SPEED COMPUTERS, II
Origin and Sponsor: Bureau of Supplies and Accounts, Department of the Navy
Manager: G. Hawkins
Full task description: July-Sept 1955 issue, p. 38
Status: Continued. The code for editing and presenting the output was
finished. Because time on the UNIVAC in the Washington area is
practically impossible to obtain, a total of only three hours of code
checking was available during the quarter. Debugging of the codes was
thus delayed.

1102-40-5126/56-157 DAMAGE ASSESSMENT
Origin and Sponsor: Office of the Assistant Secretary of Defense (Supply
and Logistics)
Managers: A. J. Hoffman, H. Bremer
Full task description: Oct-Dec 1955 issue, p. 31
Status: Continued. Meetings have been held with the sponsors in order to
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reformulate the model so that new and more extensive programs could be
be written that will more nearly represent the problem. Some of the
input programs are being written at present. There is also an interim
code to be written which will adapt routines of the past to conform with
a better representation of the input data.

1102-40-5126/56-158 FEDERAL RESERVE DATA
Origin and Sponsor: Federal Reserve Board
Manager: E. Marden
Full task description: Oct-Dec 1956 issue, p. 31
Status: Continued. Five codes were written, together with some needed
auxiliary service routines that were unavailable at the UNIVAC installations
where these tabulations were performed.
It became increasingly difficult to obtain sufficient UNIVAC time
to accomplish the desired objectives, and even time on auxiliary
machines was in short supply.
The Air Force card-to-tape machine was used to convert the
information on the approximately 200,000 punched cards to 55 UNIVAC
magnetic tapes, which were then processed (and to some extent compressed)
to form new data tapes for use in the actual tabulations. UNIVAC's
at the Census Bureau, the Army Map Service, and the Du Pont Company (in
Newark, Delaware) were used for this purpose. Tabulations, making use
of the processed data, are under way on the Du Pont UNIVAC.

1102-40-5126/56-162 STRESSES IN A WALL RESTING ON A FOOTING
Origin and Sponsor: NBS, Section 10.1
Manager: I. Stegun
Objective: To evaluate on SEAC coefficients in a stress function \( \phi \) which
is used in obtaining the stresses and strains due to shrinkage in a
concrete wall resting on a footing.
Background: The interior of a wall can be considered to be an elastic
slab which obeys the equation of elasticity. In the equation

\[
\frac{\partial^4 \phi}{\partial x^4} + 2 \frac{\partial^4 \phi}{\partial x^2 \partial y^2} + \frac{\partial^4 \phi}{\partial y^4} = 0,
\]

(1)

\( \phi \) is the stress function which gives the stresses in the wall by the
following relationships:

\[
\sigma_x = \frac{\partial^2 \phi}{\partial y^2} = \text{stress in } x\text{-direction},
\]

\[
\sigma_y = \frac{\partial^2 \phi}{\partial x^2} = \text{stress in } y\text{-direction},
\]

\[
\tau_{xy} = -\frac{\partial^2 \phi}{\partial x \partial y} = \text{shear stress}.
\]

No single expression satisfying equation (1) above and the boundary
conditions of the problem could be found. Therefore it has been decided
to obtain a solution in the form of a series of expressions, each of
which will identically satisfy equation (1) and the sum of which can be
made to satisfy the boundary conditions to any desired degree of accuracy.
The equation for the stress function used is

\[
\phi = \sum_{n=1,3,...} \sum_{m=1,2,...} a_{mn} \sin \frac{m\pi x}{a} \sin \frac{n\pi y}{b},
\]
\[ w, e \left( \begin{array}{c} a_m \\ a_n \end{array} \right) = \frac{\sum_{\text{odd}} (-1)^{\frac{n-1}{2} + p_m}}{\left( m^2 \frac{b}{a} + n^2 \frac{a}{b} \right)^2} \]

\[ a_{mn} = \frac{n^\ell_m + mt_n + (-1)^\ell_s ns_m}{(m^2 \frac{b}{a} + n^2 \frac{a}{b})^2} \]

The coefficients \( k_m, \ell_m, t_n, p_m, \) and \( s \) are to be determined by the boundary conditions. This necessitates the solution of 40 simultaneous equations for a wall twice as high as it is long, and of 60 simultaneous equations for a square wall. (For the computation of the stress function, see task 1102-40-5126/55-88, Jan-Mar 1955 issue, p. 22.)

**Status:** New. The solutions have been obtained for the rectangular wall (40 simultaneous equations) and the square wall (60 simultaneous equations). The matrix inversion codes were employed restricting the number of vectors to two—the vector of the unknowns and a check vector.

**ANGULAR DISTRIBUTIONS AND POLARIZATION EFFECTS IN NUCLEAR SCATTERING**

**Origin and Sponsor:** Naval Research Laboratory

**Manager:** I. Stegun

**Full task description:** Oct-Dec 1955 issue, p. 32

**Status:** Continued. The code was completed, and various sample problems are being run to check approximation formulae.

**INTEGRALS FOR SCATTERING FUNCTIONS**

**Origin and Sponsor:** Naval Research Laboratory

**Manager:** R. Zucker

**Full task description:** Oct-Dec 1955 issue, p. 32

**Status:** Continued. For \( \xi \gg 1 \), the value of

\[ I_{\text{LIMIT}} = \frac{8 \xi}{p^2} \left( \frac{1}{\ln(4\xi^2) - 1} \right) \]

was verified for several sets of \( p \) and \( \xi \). The code was checked out, and a sample case was run for a given set of parameters.

**SCF-LCAO SOLUTION OF SOME HYDRIDES**

**Origin and Sponsor:** NBS, Section 5.9

**Manager:** E. Haynsworth

**Objective:** To find the eigenvalues, \( \epsilon_i \), and eigenvectors, \( C_i \), of the secular equation

\[ (H+G)C = \epsilon SC \]

where \( H, G, \) and \( S \) are nxn symmetric matrices, \( n \leq 6 \). \( H \) and \( S \) are constant, but the elements of \( G \) are quadratic functions of the eigenvectors \( C_i \).

**Background:** The eigenvectors are the coefficients of the atomic orbital in the LCAO approximation to a molecular orbital, and the secular equation results from minimization of the expression for the ground state energy for the molecules considered with respect to the coefficients. (See C.C.J. Rootham, Rev. Modern Phys. 23, 69 (1951).) The problem was
Status: New. The main code has been written but has not been checked as a whole. Most of the subroutines involved, such as matrix multiplication and addition, calculation of determinants, orthonormalization of vectors, have been checked.

1102-40-5126/56-169 CRYSTAL FIELD EFFECTS FOR ATOMS
Origin and Sponsor: NBS, Division 3
Manager: I. Stegun
Objective: To compute eigenvalues and eigenvectors of matrices as functions of parameters describing various crystal fields.
Background: The calculations arise in the study of the effect of the combinations of crystal field and spin-orbit coupling on the optical and magnetic properties of solids. The problem was transmitted by C. M. Herzfeld (3, 0).
Status: New. For heavy atoms the matrix for the combined crystal field effect and spin-orbit coupling is a 33x33 matrix. This matrix factors directly into three 8x8 matrices and one 9x9. The eigenvalues and eigenvectors were obtained for ten 8x8 matrices and five 9x9 matrices. For nitrogen atoms the eigenvalues and eigenvectors were obtained for fifteen 5x5 matrices.

1102-40-5126/56-171 COLLISION INTEGRALS USED IN TRANSPORT THEORY
Origin and Sponsor: NBS, Section 3.2
Manager: J. Cooper
Full task description: Oct-Dec 1955 issue, p. 33
Status: Continued. A short code to compute the value of
\[ x = \pi - 2b \int_{r_m}^{\infty} \frac{dr/r^2}{\sqrt{1 - (b/r)^2 - \phi(r)/g^2}} \]
for various values of g and b was written to determine the behavior of x using the Morse potential:
\[ \phi(r) = 4e^{-\beta(1-r)}(e^{-\beta(1-r)} - 1). \]
To find \( r_m \) (the largest root of the denominator) the equation \( r_{n+1} = r_n - f(r_n) \), where \( f(r) \) is the expression under the radical sign in the above equation, was solved by iteration. In order to improve convergence it was found convenient to replace \( f(r) \) by \( f'(r) \) and iterate using the form
\[ r_{n+1} = r_n - \frac{f'(r_n)}{f''(r_n)}. \]
Convergence using this form in conjunction with an iteration accelerator technique was rapid, and the process converged for all cases tried except when \( \beta \) in the Morse potential was large.
The integration was performed using 16-point Gaussian quadrature on the interval 0 to 1/\( r_m \), transforming the integral using \( \rho = 1/r \).
However, due to the singularity at the upper limit the accuracy was not sufficient. The code has now been modified to compute the integral using the transformation \( \frac{1}{r} = \sin \varphi \), which removes the singularity except for certain values of the parameters b, g and \( \beta \).
NUMERICAL EVALUATION OF SPECIAL INTEGRAL EXPRESSIONS

Origin and Sponsor: Diamond Ordnance Fuze Laboratory, Department of the Army
Managers: P. Henrici, L. Joel

Objective: To evaluate some principal value integrals of the form

\[ P \int_0^\infty \frac{f(x^2)}{x^2-a^2} J_0(xy) \, dx \]

where \( f(x^2) \) is an elementary differentiable function for \( 0 < x < \infty \).

Background: Integrals of this type occur in the theory of elastic vibrations. In a report by P. W. McQuinlan, "Elastic theory of soil dynamics," p. 3 (Symposium on Dynamic Testing of Soils, ASTM Special Technical Publication No. 156, 1953), simple cases of transmission of tremors or vibrational disturbances through surface soils are presented. The current study is an attempt to complete the analysis of one unresolved aspect in this report as expressed in the above integral. The integral gives the soil vibration amplitude at a distance from the source as a function of soil parameters and experimental conditions. The results of this evaluation of Quinlan's integral will be compared with other experimental data obtained at the NBS in an attempt to check the validity of the analysis. The problem was requested by E. N. Skomal.

Status: New. In order to avoid the singularity in the numerical integration, one introduces the function

\[ g(x^2) = \frac{f(x^2) - f(a^2)}{x^2 - a^2} \]

The integral can then be written

\[ \int_0^\infty g(x^2)T_0(xy) \, dx + f(a^2) \, P \left\{ \int_0^\infty \frac{1}{x^2-a^2} J_0(xy) \, dx \right\}, \]

where \( P \{ \} \) denotes the principal part of the integral. Here the first integral has a regular integrand, and the second can be evaluated explicitly in terms of the Neumann functions.

COMPUTATIONS FOR JOB SATISFACTION INVENTORY

Origin and Sponsor: Public Health Service
Manager: S. Prusch

Objective: To determine and compare distributions of data in a job satisfaction inventory, and to compute the \( \chi^2 \) distribution for each of the 215 items in the inventory.

Background: The computations arise in connection with the study of a job satisfaction inventory for five groupings of personnel in three hospitals. An attempt is being made to check the relative validity of the 215 items with a view to reducing the number to 100. To aid in this it is necessary (1) to determine how the distribution of individuals with favorable and unfavorable responses to each item compares with the distribution of individuals with high and low scores, and (2) to determine how the distribution of individuals with favorable and unfavorable responses to an item compares with the distribution of individuals who are satisfied or dissatisfied as determined by special criteria. This was specifically requested by B. Buchbinder of the Public Health Service.

Status: New. The problem was coded, and code-checking is in progress.
Status of Projects

1102-40-5126/56-176  MODEL GOVERNMENT PAYROLL ON HIGH SPEED COMPUTERS

Origin and Sponsor:  NBS, Section 12.5

Manager:  G. Hawkins

Objective:  To investigate the feasibility of translating the Government payroll computations to electronic computer operations. This investigation is to be effected by studying in particular the conversion of the operations of the NBS payroll system (1) to a large general-purpose computer, and (2) to a drum computer, and then comparing the efficiency of these two systems with each other and with an IBM mechanized system.

Background:  The NBS payroll system was recently mechanized with IBM equipment. Biweekly time cards for each employee are submitted to the Payroll Section. From these, time cards and paychecks are computed and processed; and various division and bureau reports are derived and used for time distribution analyses and general accounting procedures. The present investigation aims to determine whether further time-saving and efficiency is possible if the material were to be processed on a digital electronic computer.

Status:  New. Coding of the problem for UNIVAC is in progress.
6. STATISTICAL ENGINEERING SERVICES

COLLABORATION ON STATISTICAL ASPECTS OF NBS RESEARCH AND TESTING
Task 3737-60-0002/51-1

Origin: NBS
Managers: W. J. Youden, J. Cameron
Full task description: July-Sept 1950 issue, p. 60

Status: CONTINUED. During this quarter members of the Section provided statistical assistance and advice to a number of Bureau personnel. The following are representative examples:

(1) A 3x3 factorial experiment in 9 blocks of 3 units each was analyzed for J. Wachtman, Section 9.1, to evaluate the characteristics of the modulus of rupture of sapphire single crystals with respect to loading rates and temperatures.

(2) Statistical analyses were made on SEAC for H. C. Allen, Section 4.2; W. G. Eicke, Section 1.2; G. W. Cleek, Section 9.2; J. Hilsenrath, Section 3.2; A. Friedman, Section 3.2; M. D. Burkhard, Section 6.1; and R. S. Jessup, Section 3.2. In the last two instances special codes were written for SEAC.

(3) Members of the staff consulted with personnel of the Fire Protection Section (10.2) on the scheduling of tests of fire protecting finishes for building materials.

(4) W. J. Youden has been working with W. B. Mann, Section 4.9, on experiment designs for the intercomparison of radium standards from several national laboratories.

(5) An analysis of the data on lengths of meter bars was made for Section 2.4 to determine the improvement in precision due to improved methods of marking lines on the newer bars.

(6) M. Zelen served as statistical consultant to the members of Section 12.5 who are studying the sorting operations of the Post Office.

Publications:


(3) A simplified calibration of platinum versus platinum-rhodium thermocouples. B. E. Squires (3.1) and M. Zelen. In manuscript.

STATISTICAL SERVICES FOR COMMITTEE ON SHIP STEEL, NRC
Task 1103-40-5105/52-1

Origin and Sponsor: Ship Structure Committee, NRC
Manager: W. J. Youden
Full task description: Oct-Dec 1951 issue, p. 58

Status: CONTINUED. A multiple regression study of the effect of chemical composition on ship steel was nearly completed.
RESEARCH IN APPLICATIONS OF MATHEMATICAL STATISTICS TO PROBLEMS OF THE CHEMICAL CORPS
Task 1103-40-5118/52-1

Origin and Sponsor: Biological Laboratories, Authorized 10/1/51
Chemical Corps, Dept. of the Army
Manager: C. Eisenhart
Full task description: Oct-Dec 1951 issue, p. 57

Status: CONTINUED. A report giving a collection of formulas for computing probabilities from common statistics was submitted. Work on tabulating a function related to problems of diffusion in the atmosphere was begun.

STATISTICAL ANALYSIS AND DESIGN OF EXPERIMENTS
FOR THE U. S. GEOLOGICAL SURVEY
Task 1103-40-5140/54-1

Department of Interior
Manager: C. Eisenhart, W. J. Youden
Full task description: Oct-Dec 1953 issue, p. 50

Status: CONTINUED. Some quick and easy methods for estimating the direction of gradient and the properties of such estimators are being worked out.

Data supplied by Dorothy Carroll of the Beltsville Laboratories concerning counts of different kinds of minerals in samples taken from tributaries of the South River in Virginia were analyzed for the most abundant mineral, the "opaques," with the aim of deciding how many samples should be taken from each location in order to get the most information for a given cost.

Consultations were held with J. Hack on application of extreme values and other statistical methods (including order statistics) to pebble deposits.

C. Eisenhart visited the U. S. Geological Survey Center, Menlo Park, California, March 19-24, at their request (i) to acquaint the geologists at Menlo Park with the uses and usefulness of statistical methods in laboratory and field studies, and with the necessity of giving adequate consideration to statistical aspects of such studies in the planning stage; (ii) to discover in what particular phases of the work going on at Menlo Park statistical methods might be most advantageously applied; and (iii), to make some tentative plans for provision of statistical assistance to the geologists at Menlo Park in the future. While there he gave five lectures to the staff of the center as follows: (1) Evolution of statistical method as a research tool; (2) Some canons of sound experimentation; (3) Principles of sampling; (4) Variance components and optimum allocation of sampling effort; and (5) Experiment designs. On the final day he presided over an informal meeting at which (1) representatives from the Department of Statistics, Stanford University, and the Statistical Laboratory, University of California, Berkeley, outlined the statistical courses of potential value to geologists available at these two neighboring educational institutions, and (2) geologists from the center outlined some of their problems to the statisticians and sought their advice on them.
Origin and Sponsor: Office of Ordnance Research
Manager: C. Eisenhart
Full task description: Oct-Dec 1954 issue, p. 28

Status: CONTINUED. Drafts of the following sections have now been completed: "Estimating average performance from a sample," "Estimating the variability of performance from a sample," "Statistical tests concerning averages and dispersions." A draft of the section "Description, prediction, and correlation" is nearly completed, and some work has been done on the sections "Simple control charts for means and ranges," "Estimating true proportions or percentages," and "Statistical tests concerning proportions."
APPLICATION of NATIONAL BUREAU OF STANDARDS AUTOMATIC COMPUTER (SEAC)

The record of SEAC operations for tasks of the Applied Mathematics Division for the period January 1 through March 31 is as follows:

<table>
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<tr>
<th>Task No.</th>
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<td>Research in numerical analysis</td>
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<td>5116/56-148</td>
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<td>Nerve fiber reaction</td>
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<td>1110/47-2</td>
<td>17</td>
<td>Tables of Coulomb wave functions</td>
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<td>Sieverts integral</td>
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<td>Radiation diffusion III</td>
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<td>L-Shell conversion coefficients</td>
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<td>Automatic coding</td>
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<td>Calculations for d-spacings</td>
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<td>5126/53-29</td>
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<td>Dynamic behavior of aircraft structure</td>
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<td>Depolymerization</td>
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<td>Spectrometer analysis</td>
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<td>0009/55-53</td>
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<td>Electronic functions</td>
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<td>Parameter of the dispersion equation for optical glass</td>
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<td>5126/55-81</td>
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<td>Combining tests for significance</td>
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<td>5126/55-87</td>
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<td>Crystal structure</td>
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<td>5126/55-97</td>
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<td>High temperature properties of air</td>
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<td>Thermometer calibrations</td>
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<td>Electron penetration</td>
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<td>Evaluation of integrals related to gas flow</td>
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<td>5126/55-127</td>
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<td>Vibrations of circular disc</td>
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<td>5126/55-166</td>
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<td>SCF-LCAO solution of some hydrides</td>
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<td>0009/56-131</td>
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<td>Ray tracing</td>
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<td>Transmission delay times</td>
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<td>Study of internuclear potential for H3</td>
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<td>5126/56-150</td>
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<td>Crystal field effects for atoms</td>
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<td>Collision integrals used in transport theory</td>
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<td>5126/56-179</td>
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<td>Normal propagation constant</td>
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<td>5126/56-178</td>
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<td>Cytac</td>
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<td>Statistical aspects of administrative operations</td>
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<td>Misc.</td>
<td>Training</td>
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<td>Least squares</td>
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<td>Other:</td>
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<td>5126/53-45</td>
<td>Award of procurement contracts for linear programming</td>
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<table>
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<th>Task No.</th>
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<td>&quot;Fuse&quot; problem</td>
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<td>Aircraft responses</td>
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<td>Complex eigenvalues</td>
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<td>Calculation of wave functions</td>
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<td>Stability of supported plates</td>
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<td>Crystal counter efficiency</td>
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<td>Multiple correlation routines</td>
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<td>Integrals for scattering functions</td>
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<td>Job satisfaction inventory</td>
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<td>Coulomb – AEC</td>
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<td>Mathematical elasticity</td>
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<td>5160/56-156</td>
<td>Mathematical geophysics</td>
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</table>
Lectures and Symposia

Note: In general, copies of papers or talks listed in this section are not available from the National Bureau of Standards. If and when a paper is to be published, it will be listed in the section of this report on Publication Activities.

Participation in NBS Scientific Staff Meetings


Applied Mathematics Division Seminar

ARONSZAJN, A. (University of Kansas) Survey of the work in progress on partial differential equations, in particular eigenvalue problems at the University of Kansas. March 9.

Seminar: Special Topics in Numerical Analysis

(Offered by the Department of Mathematics of The American University in collaboration with the Graduate School of the National Bureau of Standards)


Algebra Seminar

(Offered by the Department of Mathematics of The American University in collaboration with the Graduate School of the National Bureau of Standards)


NEWMAN, M. A theorem of Mordell concerning positive quadratic forms, I, II. February 20, 29.


Lectures and Symposia

Statistical Theory Seminar

(Offered jointly by the National Institutes of Health and the National Bureau of Standards.)


Applied Statistics Seminar

(Offered jointly by the National Institutes of Health and the National Bureau of Standards.)

MEIER, P. (Johns Hopkins University) Some statistical aspects of safety testing of vaccines. March 16.

Mathematical Physics Section Seminar


Papers and Invited Talks

Presented by Members of the Staff at Meetings of Outside Organizations


HOCHSTRASSER, U. Methods and tools in applied mathematics, (1) Presented at a meeting of Sigma Pi Sigma, Howard University, Washington, D. C., February 17, and (2) Presented to the Research and Development Group, Naval Powder Factory, Indian Head, Md., February 29.

HOFFMAN, A. J. (1) Cross sections of two families of sets. Presented at a meeting of the Logistics Research Project, George Washington University, Washington, D. C.; February 2. (2) Integral solutions of linear programming problems. Presented to the Industrial Engineering Department of Johns Hopkins University,

STONELEY, R. (Guest Worker, from Cambridge University).


SYNGE, J. L. (Guest Worker, from Institute for Advanced Studies, Dublin).


Statistics for novices. Presented at the Sixth Annual Convention Textile Division, ASQC, Charlottesville, Va., February 13.

Design of experiments. Presented before the Youngstown Section of ASQC, Youngstown, Ohio, March 1.

Design of experiments in research and development. Presented before the Washington Chapter, American Society for Metals, March 12.

Publication Activities

1. PUBLICATIONS THAT APPEARED DURING THE QUARTER

1.3 Technical Papers


Publication Activities


2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION MARCH 31, 1956

2.1 Mathematical Tables


2.2 Manuals, Bibliographies, and Indices


2.3 Technical Papers

(1) On the differential equation $\dot{x} + k(f(x) + g(x)\dot{x})\dot{x} = ke(t)$. H. A. Antosiewicz. Submitted to a technical journal.


(3) Easily used simultaneous confidence limits for a line. W. S. Connor. Submitted to a technical journal.


(7) Some Monte Carlo experiments in computing multiple integrals. P. Davis and P. Rabinowitz. To appear in Mathematical Tables and Other Aids to Computation.


(15) On the representation of a certain integral involving Bessel functions by hypergeometric series. Submitted to a technical journal.


(20) Applications of extreme value theory to cobbles and boulders in gravel pits. W. C. Krumbein (Northwestern University) and J. Lieblein. Submitted to a technical journal.


(22) An inclusion theorem for modular groups. M. Newman. Submitted to a technical journal.


(25) The diophantine equation \(ax^m - by^n = c\). M. Newman. Submitted to a technical journal.


(31) The transmission of Rayleigh waves across an ocean floor with two surface layers. R. Stoneley. Submitted to a technical journal.


(33) Some computational problems in algebraic number theory. O. Taussky. To appear in the Proceedings of the American Mathematical Society Sixth Symposium on Applied Mathematics, held at Santa Monica City College, August 1953.


2.5 Miscellaneous items

Publication Activities

(2) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau’s work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau’s work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau’s own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau’s publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau’s reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.