PROJECTS and PUBLICATIONS
of the
APPLIED MATHEMATICS DIVISION
A Quarterly Report
July through December 1962
THE NATIONAL BUREAU OF STANDARDS

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A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.
PROJECTS and PUBLICATIONS
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July through December 1962

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December 31, 1962

1. NUMERICAL ANALYSIS

RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS
Task 1101-12-11110/55-55

Origin: NBS
Manager: Philip J. Davis
Full Task Description: July-September 1954 issue, p.1 Authorized 8/29/54

Status: CONTINUED. P. Davis has completed and submitted to a technical journal a paper entitled "Packing Inequalities for Circles" which derives from complex variable and functional analysis various inequalities satisfied by non overlapping discs lying in the unit disc.


P. Davis, in collaboration with L. Joseph of 11.2 and M. Klein of Division 3.08 has been conducting numerical experiments toward the computation of highly multiple integrals. More specifically, he has been attempting to compute the fourth and fifth virial coefficients of an imperfect gas, utilizing a fairly arbitrary interaction potential. Despite a flurry of activity on this problem over the past five years the numerical aspects of the problem can hardly be said to be solved satisfactorily at the present time. Exploratory computations have been made using Monte-Carlo methods and our experience has lead us to the conclusion that even on a machine of the speed of the 7090 fairly substantial blocks of time would be required. The problem of multiple integration is still relatively uninvestigated and there is much to be done theoretically, numerically, and on ad hoc problems.

P. Davis and K. Kloss have been working on minimum problems that arise in the determination of quadrature rules of high dimension. It has been found that naive techniques of minimization are too inefficient to be of much good.

F. W. J. Olver has completed a second paper on error bounds for the asymptotic solutions in terms of Airy functions of second-order ordinary linear differential equations in regions containing a turning point, which gives extensions to complete asymptotic expansions and to
Status of Projects

complex variables. He is now investigating error bounds for J. C. P. Miller's algorithm for the computation of functions from recurrence relations.

O. Shisha has worked in the following areas: (i) Techebycheff approximation by rational functions and by polynomials, particularly from the computational point of view; (ii) Infra-polynomials with prescribed coefficients (including work with Prof. J. L. Walsh); (iii) Fractional order differences of the coefficients of polynomials (with Dr. G. T. Cargo); (iv) Inequalities between means (with Dr. G. T. Cargo).

S. Haber is preparing a survey of the theory of equidistribution mod one. He suggested the use of the sequences \(\{K^2\alpha\}\), \(\alpha\) irrational, as quasi-random numbers in Monte Carlo quadrature, and showed that the usual \(1/n\) error estimate can then be given a precise meaning.

W. Gustin and K. Kloss worked in the following areas: (i) Combinatorial problems. A new type of oriented block design which splits into several block designs was formulated. All solutions for the first few cases of a special design \(T_i\) \((i = 1, 2, 3, ...\) which splits into two Steiner triples were obtained by the computing machine. It is hoped that this data will implement insight into a general solution of the design \(T_i\); (ii) Function maximization. A program was designed for searching out a maximum of a real function on an \(n\) dimensional cube as follows. The cube is first searched randomly, with maximal functional value and location thereof retained, until \(k\) consecutive points have been examined without improvement of the running maximum. Then around the best point so far obtained a cubical neighborhood of just such size as not likely yet to have been otherwise penetrated is randomly searched, again until consecutive unsuccessful contracts the search neighborhood. Search ends after a certain number of such contractions, or can begin anew.

Maxine Rockoff has continued to study the numerical solution of the system of linear equations \(Ax = b\) resulting from a finite difference analog of the Dirichlet problem for Poisson's equation with an \(O(h^4)\) estimate for the truncation error proposed by Bramble and Hubbard [Num. Math. Dec. 1962]. The approximation at irregular interior points is not of positive type. Here \(A = I - L - U\) where \(L\) and \(U\) are strictly lower and upper triangular matrices respectively. Define \(\rho(H)\) to be the spectral radius of \(H\). Let \(s_{\omega} = [I - \omega L]^{-1} [\omega U - (\omega - 1) I]\) be the matrix defining the method of successive overrelaxation as developed by Young [Trans. Am. Math. Soc., 76, 1954.] \(L + U\) is neither symmetric nor non-negative, however \(S(L + U) < 1\). It is shown that an ordering can be found such that \(s_1\) and \(L\) are non-negative. For this ordering it is shown that

\[\rho(s_1) < \rho(L + U).\]

Further, there exists an \(\bar{\omega} > 1\) such that for \(1 < \omega < \bar{\omega}\), \(\rho(s_\omega) < \rho(s_1) - [\omega - 1] [1 - \rho(s_1)]\). These results generalize parts of the results of Stein and Rosenberg [Journ. Lond. Math. Soc., 23, 1948]
Status of Projects


R. DeMar studied the following problems: 1. To find conditions of a sequence \( \{a_n\} \) of real numbers in order that the class \( K \) of all entire functions satisfying

\[
\limsup_{|y| \to \infty} |f(iy)| < \pi
\]

be a uniqueness class for \( \{\Delta^n f(a_n)\} \), i.e., in order that \( f \in K \) and \( \Delta^n f(a_n) = 0, n = 0, 1, 2, \ldots \) imply \( f = 0 \). The following theorem was proved:

If \( \{a_n\} \) is a periodic sequence of period \( p \) with each period an arithmetic progression with difference \( \beta < 0 \), then \( K \) is a uniqueness class for \( \{\Delta^n f(a_n)\} \) if and only if \( \beta < 1/(p - 1) \). 2. The complex Pompeiu problem (in collaboration with Philip Davis). This is the problem of finding uniqueness classes for functionals defined on \( L_2(B) \) by

\[
\mathcal{L}_T^f = \iint_B f(T(z))g(z)dx \, dy
\]

for a given region \( B \) and function \( g \) where \( T \) ranges over some class \( G \) of Euclidean transformations. Results have been obtained for \( G \) a class of rotations of the plane; for \( G \) a class of translations, and for \( G \) a class including rotations and translations.

E. C. Johnsen has been investigating various combinatorial problems in the area of \( v, k, \lambda \) block designs, in particular questions with regard to the uniqueness of general cyclic designs and to the existence of special types of such designs. The investigation of the latter problem has been progressing steadily since it was started and its end appears in sight, at least in certain parts.

Publications:


(3) On the maximum number of zeros in the powers of an indecomposable matrix. M. Marcus and F. May. Submitted to a technical journal.


(6) Lower bounds to eigenvalues using operator decomposition of the form...
Status of Projects


(7) Linear operations on matrices. M. Marcus. In manuscript.


(14) Error bounds for asymptotic expansions in turning-point problems. F. W. J. Olver. In manuscript.


(16) Error analysis of Miller's recurrence algorithm. F. W. J. Olver. In manuscript.
RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO
NUMERICAL ANALYSIS
Task 1101-12-11411/55-56

Origin: NBS
Sponsor: Office of Naval Research
Manager: Morris Newman
Full Task Description: July-September 1954 issue, p. 5

Status: CONTINUED: M. Newman and J. Lehner initiated a study of the
Weierstrass points of the groups $\Gamma_0(n)$. It was shown that the cusps $0, i, \infty$ of the fundamental region of $\Gamma_0(n)$ are always Weierstrass points of $\Gamma_0(4n), \Gamma_0(9n)$ in all cases for example when $n > 1$ is neither a prime nor
the product of two distinct primes; and it was shown that the fixed
points of certain linear fractional transformations belonging to the
normalizer of $\Gamma_0(n)$ are always Weierstrass points of $\Gamma_0(n)$.

M. Newman proved that with three exceptions, any normal subgroup of
the modular group $\Gamma$ is a free group. The exceptions are $\Gamma^F_r$ ($r = 1, 2, 3$)
where $\Gamma^F$ is the subgroup of $\Gamma$ generated by the $r$ th powers of the elements
of $\Gamma$.

Tables of genera for certain groups of linear fractional transformations
and of class numbers of positive binary quadratic forms have been computed
by E. Ordman and H. Fell, at the suggestion of M. Newman.

K. Goldberg and Jane Gager Reed continued their development of a model
of a certain type of competitive human behaviour, concentrating on an
attempt to randomize the input data sufficiently to achieve a random out-
put consistent with known results.

K. Goldberg continued his investigation of the coefficients of the
powers of the iterates of a formal power series. In this connection he
began an investigation of "symmetric function recursions" of the type

$$f_n(p_1, \ldots, p_n) = \sum_{i=1}^{n} K(p_1^{(i)}, \ldots, p_m^{(i)}) f_{n-1}(p_1^{(i)}, \ldots, p_{n-1}^{(i)})$$

where $p_r = \sum_{j=1}^{n} x_j^r$ and $p_r^{(i)} = p_r - x_1^r$.

K. Goldberg has derived several formulas for the coefficients in the
$s$ th power of the $t$ th iterate of a power series $f(z) = z + \ldots: \{f^t(z)\}^s$
$= z \sum_{n=0}^{\infty} a_n^{(s)}(t) z^n$. The starting point is the triangular matrix $M^f_{t-1}$
$= (a_n^{(1)}(1))$ which has the composition property $M^f_{t} M^g_f = M^g_{t f}(g)$, and the new
result that $\log M = D C_f$ where $D = \text{diag}(1, 2, \ldots)$ and $C_f$ is a circulant:

$C_f = \text{circ}(0, c_1, c_2, \ldots)$. This leads to the formula
Status of Projects

\[ s_n^{(s)}(t) = s \sum P_{k_1, k_2, \ldots}^{(1, \ldots, s)} c_1 \ldots c_n \frac{\sigma_k}{k_1! \ldots k_n!} \]

summed over the partitions \( k_1 + 2k_2 + \ldots + nk_n = n \), with \( k_1 \) denoting \( 1 \) repeated \( k_1 \) times, etc.

\[ P_m(x_1, \ldots, x_m; s) = \frac{1}{m!} \sum (s + x_1) (s + x_1 + x_2) \ldots (s + x_1 + \ldots + x_{m-1}) \]

the sum taken over all permutations of \( x_1, \ldots, x_m \). The problem thus reduces to an independent study of the coefficient of \( s^{m-k} \) in \( P_m \); e.g. it is the coefficient of \( w^{m-1} \) in

\[ \frac{1}{(m-k)!} \sum_{r=1}^{m-1} (-1)^{m-1-r} b_r (m) \sum_{i=1}^{r} \prod_{i=1}^{r} (e^{y_i} - 1)/wy_i \]

where the \( b_r (m) \) are positive integers and the interior sum is taken over all \( y_i \) which are the sum of distinctly indexed \( x_j \) such that \( y_1 + \ldots + y_r = x_1 + \ldots + x_m \).

Publications:


(4) Hadamard matrices of order cube plus one. K. Goldberg. In manuscript.


2. MATHEMATICAL TABLES AND PROGRAMMING RESEARCH

MATHEMATICAL TABLES

The following long-range mathematical table projects are being carried in the Computation Laboratory. Progress continues as dictated by the relative priority in the overall program of the Laboratory and by available funds. All of the table projects were inactive during the past quarter because priority was given to the preparation of the forthcoming "Handbook of Mathematical Functions."

1102-40-11112/47-2 TABLES OF COULOMB WAVE FUNCTIONS
1102-40-11112/51-8 TABLES OF POWER POINTS OF ANALYSIS OF VARIANCE TESTS
1102-40-11112/52-37 TABLES OF SPHEROIDAL WAVE FUNCTIONS
1102-40-11112/52-57 TABLES OF THE SIEVERT INTEGRAL

HANDBOOK OF MATHEMATICAL FUNCTIONS
Task 1102-40-11421/57-216

Origin and Sponsor: National Science Foundation Authorized 12/27/56
Manager: Irene A. Stegun
Full task description: October-December 1956 issue, p. 10

Status: CONTINUED. The entire volume is in press, with galley proofs received and checked for 24 of the 29 chapters.

AUTOMATIC CODING
Task 1102-11120/55/65

Origin: NBS Authorized 9/29/54
Manager: J. Wegstein
Full Task Description: July-September 1954 issue, p. 11

Status: CONTINUED. K. Berk prepared illustrative test programs and recipes for using the IPL V and COMIT compilers. These compilers, along with simplified directions for their use on the NBS 7090 computer are now available as special research tools in heuristic programming, logical programming, and symbol manipulation.

The study of string languages continued. Translations of numerous simple mechanical languages have been examined in the course of searching
Status of Projects

for features which these translations have in common.

Publication:

3. PROBABILITY AND MATHEMATICAL STATISTICS

MISCELLANEOUS STUDIES IN PROBABILITY AND STATISTICS
Task 1103-12-1131/51-2

Origin: NBS
Manager: Joan R. Rosenblatt
Full task description: July-September 1950 issue, p. 58

Status: TERMINATED. Studies hitherto reported under this task will in future be reported under Task 1103-12-1131/63-1259 (see page 58).

Janace Speckman is completing a study of unsatisfactory properties of confidence intervals based on small samples. For samples from a normal distribution with unknown standard deviation $\sigma$, Miss Speckman has obtained (1) the distribution of the half-lengths of the intervals and, (2) the (conditional) probability that a confidence interval of length $2r$ will fail to cover the mean. The probability that a confidence interval will miss including the true mean by an amount in absolute value at least $\Delta \sigma$ has been obtained for small sample sizes for the case of known $\sigma$ as well as for the case of unknown $\sigma$.

Continuing his study on application of information theory to tests for contingency tables, H. H. Ku worked out a correction for the value of the information statistic for the case where zero frequencies are involved.

George Weiss has completed two papers: "An analysis of pedestrian queueing" and "Laguerre expansions of successive generations of a renewal process".

Publications:

(3) Tests for contingency tables and Markov chains. S. Kullback (George Washington University), M. Kupperman (George Washington University), and H. H. Ku. Technometrics 4, 573-608, November 1962.
(4) An application of information theory to the analysis of contingency tables, with a table of $2n \log n$, n=1(1)10,000. S. Kullback (George Washington University), M. Kupperman (George Washington University), and H. H. Ku. Journal of Research NBS, 66B, 217-243, October-December 1962.
Status of Projects


(7) Precision of simultaneous measurement process. W. A. Thompson, Jr. Submitted to a technical journal.


STUDIES IN THE MATHEMATICS OF EXPERIMENT DESIGN
Task 1103-12-11131/53-1

Origin: NBS
Manager: J. M. Cameron
Full task description: October-December 1952 issue, p. 60

Status: TERMINATED. Studies hitherto reported under this task will in future be reported under Task 1103-12-11131/63-1259 (see page 11).

Marvin Zelen (U.S. Army Mathematics Research Center) has completed a paper on "The role of constraints in the theory of least squares". Work on this paper was begun at the Bureau.

Publications:


STUDY OF NONPARAMETRIC STATISTICAL TECHNIQUES
Task 1103-12-11131/56-170

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

Status: TERMINATED. Studies hitherto reported under this task will in future be reported under Task 1103-12-11131/63-1259 (see page 11).

The paper "On a rank sum test for outliers" by W. A. Thompson and T. A. Willke has been submitted for publication. This paper contains two-sided tables for the test.
Status of Projects

Publications:
(1) On a rank sum test for outliers. W. A. Thompson, Jr. and T. W. Willke. Submitted to a technical journal.

RESEARCH IN PROBABILITY AND MATHEMATICAL STATISTICS
Task 1103-12-1131/63-1259

Origin: NBS
Manager: Joan R. Rosenblatt

Objective: To conduct mathematical research on the theory and techniques of statistical inference and statistical design of experiments, and on applications of probability theory, with special reference to problems that arise in physical science and engineering experimentation; and to disseminate the results of such work in the form of research papers, and to of statistical methods, special tables, and other aids to applied statistics.

Background: Problems in physical science and engineering experimentation require adaptation and extension of existing statistical theory and method and new applications of probability theory to the development and analysis of mathematical models. There is a continuing need for new experimental arrangements suited to the needs of measurement and experimentation in the physical sciences, and for the related development of methods of data analysis. There is a growing parallel need for critical appraisals of the performance of statistical techniques when underlying assumptions are not exactly satisfied, and for guides for choosing among alternative techniques.

Specific tasks will generally belong to one or more of the following interrelated categories. (1) Design of experiments, (2) Nonparametric statistical techniques, (3) "Practical properties" of statistical techniques, including questions of power, efficiency, robustness, consequences of misapplications, (4) Probabilistic models and statistical methods developed for special needs in the physical sciences and in metrology, (5) Preparation of tables, manuals, bibliographies, and other special aids for research work.

Comment: This task supersedes several whose objectives were more narrowly specified, and which are terminated this reporting period. The tasks terminated are:
1103-12-11131/51-2 (Misc. studies in probability and statistics),
1103-12-11131/53-1 (Studies in the mathematics of experiment design),
1103-12-11131/56-170 (Study of nonparametric statistical techniques).
Status of Projects

(1) Design of Experiments. J. M. Cameron has written a paper on "An algorithm for obtaining an orthogonal set of individual degrees of freedom for error". Based on the Gram-Schmidt orthonormalization procedure, the algorithm produces the coefficients of linear combinations of observations which can be used for computing an orthogonal set of individual degrees of freedom for error from a set of observations. The algorithm is applicable in the analysis of data from designed experiments, and especially in the analysis of residuals (deviations between observed and predicted values) when these are used to study the state of statistical control of a measurement process.

Two additional notes by J. M. Cameron treat computational problems arising in the analysis of designed experiments: "The generalized inverse of a real symmetric matrix", and "An easy method for computing the variance of a predicted value in a regression problem".

(2) Nonparametric statistical techniques. The one-sided tables for the rank sum test for outliers have now been computed. In order to study the performance of this test, calculations of the power under various alternatives have been carried out by T. A. Willke. For comparison purposes similar power calculations for a standard parametric test and the maximum absolute deviate have also been done. A formal generalization of the rank sum test has been written out by which other parameters besides the mean can be tested with the same tables.

(3) "Practical properties" of statistical techniques. John Van Dyke is completing a note on "Fitting $y = \beta x$ when the variance depends on $x". Results are given concerning the selection of a method for estimating the slope of a straight line through the origin when the variance of $y$ is proportional to $x^p$, and either $p$ is not known, or $p$ is known but is not an integer. The variance of the estimated slope, and the estimation of this variance, are considered.

(4) Monograph on precision and accuracy. A monograph on the definition and evaluation of the precision and accuracy of measurement systems is in an early stage of preparation under the general direction of Churchill Eisenhart. The proposed monograph is to include sections on basic concepts of the statistical theory of errors, on fundamental principles and techniques of statistical inference, and on statistical methods useful for ascertaining whether a measurement process is in a state of statistical control, for detecting and identifying particular types of systematic error and components of random variation. The aim is to present a unified treatment of the problems arising in realistic definition and evaluation of the precision and accuracy of measurement processes for the calibration of measuring instruments and standards.

Publication:

Status of Projects

NBS, Section B (Mathematics and Mathematical Physics).

MEASUREMENT OF RELIABILITY
Task 1103-12-1130/56-182

Origin: NBS
Manager: Joan R. Rosenblatt
Full task description: January-March 1956 issue, p. 13

Status: CONTINUED. George Weiss completed a paper on a study of systems with spare parts in which it is assumed that the spare parts can fail in storage as well as in use.

Weiss has initiated a study of periodic inspection policies for systems with non-exponential reliability functions.

Joan R. Rosenblatt completed a revised and expanded version of her paper on "Confidence limits for the reliability of complex systems".

Albert Romano is studying mathematical models for the description of changes through time in the probability distributions of characteristics of (e.g.) electronic devices. The dependence of these distributions on age and stress level is being considered. Mathematical models of this type will be useful in connection with the design and analysis of "life test" experiments which provide measurements of characteristics of the devices under test in addition to lifetime data. In particular, he is investigating the applicability of a family of log-normal distributions for use in describing the effect of age and stress level on certain electrical characteristics of transistors.

Publications:


4. MATHEMATICAL PHYSICS
RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS
Task 1104-12-1141/55-57

Origin: NBS  
Manager: W.R. Pell
Full task description: July-September 1954 issue, p. 27

Status: CONTINUED. A. Ghaffari is continuing the study of periodic solutions of non-linear non-autonomous differential equations by the use of the so-called "stroboscopic method" of Minorsky and the Mandelstam-Papalexi (M.P.) method. Both methods are the same at the outset, but the practical difficulties of obtaining quantitative results are, however, quite different in the two methods. In the latter instance the existence of a periodic solution is relatively simple to establish, but the question of stability is more difficult to answer. In the stroboscopic method the problem of stability is easy to study, but the formulation of the conditions of periodicity leads to the application of the stroboscopic procedure in which the constants of the linear solution appear as variables of the transformation, and the major part of the calculations concerns the determination of stationary values of these constants.

Dr. Ghaffari presented a paper at the International Congress of Mathematicians, Stockholm, Sweden, August 15-22, 1962 which summarized the application of the stroboscopic method to the Duffing equation with viscous damping. Some results concerning conditions for existence and stability of solutions were obtained.

Currently, the connection between the stroboscopic method and the asymptotic methods of the Kryloff-Bogoliubov-Mitropolsky (K.B.M.) are under study.

B. Bernstein, with E. A. Kearsley (6.05) and L. Zapas (6.05), have completed a manuscript entitled "A Study of Stress Relaxation with Finite Strain". In this paper two simple types of constitutive equations appropriate to materials exhibiting elasticity are presented, one applicable to materials which are basically solid in nature and the other to fluid-like materials. There are simplified versions of Green-Rivlin and Coleman-Noll equations, with, however, additional assumptions which seem reasonable on the basis of experience, and which yield constitutive equations simple enough to be subjected to experimental verification. Mr. Zapas has obtained preliminary experimental data which is in good agreement with the theory of Bernstein and Kearsley.

A paper covering this investigation was given at the annual meeting of the Society of Rheology, Johns Hopkins University, Baltimore, Maryland, Oct. 29-31, 1962. Dr. Bernstein also gave lectures on this work at several universities.

Drs. L. E. Payne and J. H. Bramble are continuing their application of bounding techniques to the approximate solution of problems in elasticity. They have recently finished work on pointwise bounds for the classical
Plate problems, i.e., on the solution of
\[ \Delta u = f \]
subject to one of the following sets of boundary values

i) \[ u = g, \quad \partial u / \partial n = h \]

ii) \[ u = g, \quad M(u) = h \]

iii) \[ M(u) = g, \quad Q(u) = h \]

where \( M \) is the moment at the boundary and \( Q \) is the modified shear force condition of the Kirchhoff plate theory. The \( g \) and \( h \) are prescribed functions in each case satisfying rather liberal conditions.

More recent work is concerned with the effect of errors in the elastic moduli on bounds for the solutions of the Navier equations.

Publications:


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DYNAMICS OF PLASMAS
Task 1104-12-11417/62-1157

Origin: NBS
Authorized 10/3/61
Sponsor: National Aeronautics and Space Administration
Manager: C. M. Tchen
Full task description: October-December 1961 issue, p. 12

Status: CONTINUED. C. M. Tchen has continued his investigation on plasma oscillations with collective correlation. Longitudinal oscillations in an unbounded, rarefied plasma were studied by including the effects of the correlation function. Since it is the collective behavior in the plasma which sets up the oscillations, its roles both in the singlet distribution function and in the pair correlation function were investigated. The dispersion relation for oscillations was obtained, and the Landau damping was calculated. A manuscript on this work is being prepared for publication.

C. M. Tchen and E. Minardi have made a study of the unsteady structure of the pair correlation function, by assuming a predominant self-consistent field, as compared to the collisions. A manuscript is in preparation.

The problem of the expansion of a plasma into a vacuum in the presence of a magnetic field is also under investigation from the magnetohydrodynamic approach by C. M. Tchen, W. L. Sadowski, and E. Minardi. The possibility of solving the kinetic equation of the Vlasov type in one dimension numerically is also being considered.

Publications:


PLASMA RESEARCH
Task 1104-12-11140/59-422

Origin: NBS
Authorized 6/30/59
Manager: C. M. Tchen
Full task description: April-June 1959 issue, p. 15

Status: CONTINUED. Dr. C. M. Tchen is continuing his investigation in the kinetic theory of plasmas. A kinetic equation valid for rapidly varying plasmas has been derived. Its theory is based on an hierarchy of equations for the distribution functions used earlier by Tchen (see Phys. Rev. 114, 394(1959)) for the derivation of a kinetic equation for a moderately varying plasma. The rapid processes involved in the correlation
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function modified the screening behavior of plasmas. The result degenerated to the earlier one for the special case of moderately varying plasmas. A paper covering this development is in preparation.

Dr. Tchen has investigated the possibility of formulating a kinetic foundation for the theory of turbulence, using the approach of BBGKY equations. The three lengths (Kolmogoroff's microscale, vorticity scale, and inertia scale) as formulated by the dissipation, viscosity, and energy could be compared with the three scales in plasmas, and therefore the BBGKY equations were possible for iterations and applied to turbulence, considered as a system with weak but long range interaction. It was intended to first derive some known results from this approach, find the relation between the spectral function and the probability function, and to clarify the relations between the temporal, spatial, and time-space auto-correlation functions.

THEORY OF SATELLITE ORBITS
Task 1104-12-11441/62-1166

Origin: NBS
Sponsor: National Aeronautics and Space Administration
Manager: J. P. Vinti
Full task description: January-March 1962 issue, p. 12

Status: CONTINUED. J. P. Vinti is continuing his study of the orbits of satellites with the aid of the gravitational potential associated with his name.

The earlier method of handling the residual fourth harmonic in the gravitational potential yielded Poisson terms in the element $G$. Choice of a new set of Delaunay elements $L$, $G$, $H$, $I$, $g$, and $h$ eliminates Poisson terms and leads to the following results.

$H$ is constant, $L$ equals a constant plus a short-periodic term proportional to $\sigma = J_4 + J_2$, and $G$ equals a constant plus short periodic and long-periodic terms proportional to $\sigma$. Each of the elements $L$, $g$, and $h$ has a secular part independent of $\sigma$, secular and short-periodic terms proportional to $\sigma / J_2^2 = 0(J_4)$. The long-periodic terms contain a denominator $\nu_2 - \nu_1 \approx 1 - 5H^2 / G^2$, where $\nu_2$ and $\nu_1$ are respectively the mean $\gamma_\nu$ frequency and the mean $\rho$ frequency. Thus the critical $\rho$ inclination appears. (These terms disappear for the intermediate orbit, for which $\sigma = 0$.)

The perturbation theory for these Delaunay elements has been carried out by the von Zeipel-Brouwer method, with only the short-periodic terms remaining to be found in detail as derivatives of a certain complicated
Status of Projects

function $S_1$.

The further solution consists in replacing, in Eqs. (8.2) and (8.3) of J. Vinti, NBS J. Res. 65B, 169-201 (1961), the quantities $t + \beta_1$ and $\beta_2$ by certain linear combinations of $\lambda$ and $g$ and solving these equations. A method is being developed for doing this by beginning with the solution for $\sigma = 0$, given in the above paper. This solution will yield the spheroidal coordinates $\rho$ and $\eta$ and thus the polar coordinates $r$ and $\theta$. Substitution of a certain linear combination of $\lambda$, $g$, and $h$ into Eq. (8.50) of that paper will then yield the right ascension $\varphi$. The constant orbital elements will then be $a''$, $e''$, $I''$, $\lambda''_0$, $\epsilon''_0$, and $h''_0$.

Publications:


5. OPERATIONS RESEARCH

OPERATIONS RESEARCH
Task 1105-12-1115/61-546

Origin and Sponsor: NBS
Manager: Alan J. Goldman
Full Task Description: October-December 1960 issue, p. 3

Status: CONTINUED. The following investigations in various fields of operations research were carried out by members of the staff:

(i) Bernice Bender continued work on simplification rules for Boolean functions, and continued preparation of a paper concerning her recent investigation of essential-cell content.

(ii) Mrs. Bender and A. J. Goldman extended previous results on overflow rate in a buffered sorting system.

(iii) A.J. Goldman participated in a survey of present and potential Federal activity in the area of transportation research.

(iv) W. Sillars, C. Witzgall and A. J. Goldman continued investigating mathematical models of distribution networks.

(v) D. Kleinman developed a computer program to simulate a particular type of sorting device. He also investigated the appearance of repeating initial blocks of digits in the representation of numbers in (0,1) to various bases.

(vi) A. J. Goldman is collaborating with M. Zelen (Mathematics Research Center, U. of Wisconsin) on a paper dealing with least squares estimation.

(vii) C. T. Zahn, Jr. completed his paper on optimal approximations of certain classes of binary relations by equivalence relations.

Publications:


AIR DEFENSE  
Task 1105-12-11415/61-544

Origin and Sponsor: U. S. Army Air Defense Command  
Manager: Lambert S. Joel

Full Task Description: July-September 1961 issue, p. 12

Status: CONTINUED. L. S. Joel and C. T. Zahn, Jr. continued coding the first simulation model. L. S. Joel and A. J. Goldman continued cooperation with members of Denver Research Institute on model formulation. B. K. Bender examined some related mathematical problems.

COMBINATORIAL MATHEMATICS  
Task 1105-12-11455-1205

Origin: NBS  
Sponsor: Army Research Office (Durham)  
Managers: Jack Edmonds & Christoph Witzgall

Status: CONTINUED. John Mather and Jack Edmonds obtained the following results (everything is semi-linear).

A (finite) 2-complex can be immersed (locally imbedded) in $E^3$ if and only if it can be imbedded in some 3-manifold. Sufficiency is based on two rather surprising lemmas: (1) If a regular neighborhood $N$ of the 1-skeleton of a 2-complex $k$ can be imbedded in $E^3$ then it can be imbedded so that, for each 2-cell $D$ of $k$, the annulus $D \cap N$ has "an even number of twists." (2) The latter type (and only the latter type) imbedding of $N$ can be extended to an immersion of $k$. An easily verifiable combinatorial description is given for such complexes. The Poincaré conjecture is equivalent to:

If a simply connected 2-complex can be immersed in $E^3$ then it can be embedded in $E^3$. The "immersotopy classes" of a graph in $S^2$ are characterized; the corresponding result for $k$ in $E^3$ is tentative.

Jack Edmonds drafted a paper on his algorithm for maximum matchings and related graph-theoretic material. C. Witzgall and C. T. Zahn, Jr. began work on computer implementation of the algorithm, and developed new variants and additional theoretical results.
6. MATHEMATICAL AND COMPUTATIONAL SERVICES

1102-40-11645/56-0166 SCF-LCAO SOLUTION OF SOME HYDRIDES
Origin and Sponsor: NBS, Section 5.9
Manager: P. J. Walsh
Full Task Description: January-March 1956 issue, p. 27
Status: Continued. Program tapes have been constructed for Hartree-Fock SCF calculations of $T_d$, $XH$, and $C_{2v}$ $XH$ molecules. Calculations have been completed for five of the accessible molecules and is in progress for others. A program tape for $C_{2v}$ $XH$ systems will shortly be ready; the integral programs have been completed for this symmetry.

1102-40-11645/56-0186 MECHANICAL MEASUREMENTS OF GAGE BLOCKS
Origin and Sponsor: NBS, Section 2.5
Manager: B. S. Prusch
Full Task Description: July-September 1956 issue, p. 33
Status: Continued. Computations for 38 sets of gage blocks were completed.

1102-40-11647/58-0266 DEPOLYMERIZATION PROCESSES
Origin and Sponsor: NBS, Section 7.6
Manager: Maxine L. Rockoff
Full Task Description: July-September 1957 issue, p. 36
Status: Continued. See also description in April-June 1962 issue, p. 32, under task 1102-40-11647/62-1209. Code has been completely checked. Production runs have begun. Sponsor is analyzing computer results and comparing them with experimental data.

1102-40-11645/58-0339 COMPUTATION OF VISCOELASTICITY PROPERTIES OF MATERIALS
Origin and Sponsor: NBS, Section 3.4
Manager: H. Oser
Full Task Description: January-March 1958 issue, p. 38
Status: Continued. A paper entitled "A Model for the Viscoelastic Behaviour of Rubberlike Polymers Including Entanglement Effects" by R. S. Marvin (Div. 6.05) and H. Oser was submitted to the NBS Journal of Research for publication in the Oct.-Dec. 1962 issue.

1102-40-11645/58-0366 RADIATION PATTERNS OF ANTENNAS
Origin and Sponsor: U.S. Information Agency, Department of State
Manager: P. J. Walsh
Status of Projects

Full Task Description: April-June 1958 issue, p. 35
Status: Reactivated. Production runs were made and results submitted to the sponsor.

1102-40-11645/58-0368  INTENSITY FUNCTIONS OF SCATTERED LIGHT
Origin and Sponsor: U. S. Army Signal Research and Development Laboratories
Manager: H. Oser
Full Task Description: July-September 1958 issue, p. 32
Status: Completed.

1102-40-11645/60-0476  GAS TUBE CHARACTERISTICS, II
Origin and Sponsor: Diamond Ordnance Fuze Laboratories
Manager: H. Oser
Full Task Description: October-December 1959 issue, p. 30
Two talks were presented at the ACM-One-Day-Washington Symposium ("Computers in the Space Age"):
Further investigations on the influence of various parameters in the time-dependent equations are conducted by the sponsor.

1102-40-11645/60-0486  MORSE WAVE FUNCTIONS AND FRANCK-CONDON FACTORS
Origin and Sponsor: NBS, Section 3.0
Manager: Ruth Zucker
Full Task Description: January-March 1960 issue, p. 28
Status: Production runs were made and results submitted to the sponsor.

1102-40-11645/60-0513  RADIATIVE ENVELOPES OF MODEL STARS
Origin and Sponsor: National Aeronautics and Space Administration Managers: P. J. Walsh and S. Haber (11.1)
Full Task Description: July-September 1960 issue, p. 23
Status: Incative.
Status of Projects

1102-40-11645/61-0530  SPECIMEN WAVE LENGTH
Origin and Sponsor:  NBS, Section 9.4
Manager:  L. Joseph
Full Task Description:  July-September 1960 issue, p. 28
Status:  Terminated.  Trial runs indicated the objective was not feasible.

1102-40-11645/61-0531  HEAT TRANSFER IN CRYSTALS
Origin and Sponsor:  NBS, Section 3.1
Manager:  H. Oser
Full Task Description:  July-September 1960 issue, p. 29
Status:  Terminated.  Production continued under direct control of the sponsor.

1102-40-11645/61-0538  SPECTRAL REFLECTANCE
Origin and Sponsor:  NBS, Section 9.4
Managers:  S. Haber (11.1) and P. J. Walsh
Full Task Description:  October-December 1960 issue, p. 23
Status:  Continued.  New Programs were written and corrected and further numerical experiments performed.  Formulas using terms corresponding to two distinct free-electron families were investigated and some were found which gave a much better overall fit of the observed data than obtainable with formula containing only one free-electron term.

1102-40-11645/61-0540  DIFFUSION CALCULATIONS
Origin and Sponsor:  Army Chemical Center
Manager:  L. Joseph
Full Task Description:  January-March 1961 issue, p. 21
Status:  Terminated.  Production runs were made and results submitted to the sponsor.

1102-40-11645/61-0556  TCHEBYCHEFF APPROXIMATION BY RATIONAL FUNCTIONS
Origin and Sponsor:  NBS, Section 11.1
Manager:  P. J. Walsh
Full Task Description:  January-March 1961 issue, p. 22
Status:  Terminated.  Further work on this task will be described under task 0055.
Status of Projects

1102-40-11645/61-0560 MUSCLE FLEXING
Origin and Sponsor: National Naval Medical Center
Manager: H. Oser
Full Task Description: April-June 1961 issue, p. 22
Status: Terminated.

1102-40-11645/62-1009 MONTE CARLO NEUTRON STUDIES
Origin and Sponsor: NBS, Section 4.3
Manager: Sally T. Peavy
Full Task Description: April-June 1961 issue, p. 21
Status: Continued. The special random number routine is checked and ready for the sponsor. The interpolation routine is in the process of being checked.

1102-40-11647/62-1022 CALCULATIONS FOR SPECTRUM OF DIPOLE RADIATION
Origin and Sponsor: Naval Research Laboratory
Manager: R. J. Arms
Full Task Description: April-June 1958 issue, p. 33
Status: Continued. A new code has been checked out. Results have been submitted to the sponsor.

1102-40-11645/62-1027 NEW SYSTEM
Origin and Sponsor: NBS, Section 11.2
Manager: J. H. Wegstein
Full Task Description: July-September 1961 issue, p. 22
Status: Continued. A study of a monitor system for the disk memory, 7090 and 1410 computers indicated that it would not be practical to develop a stored program system because of the large open-shop programming requirements. The 1410 computer was acquired in December without the disk memory.

The IBM System (IBSYS) was obtained and tested by R. Herbold. Simple example problems were run which will be available for a programmers guide to the system. IBSYS and the Bell System are now available to programmers but no further updating of the Bell System will be made in anticipation of its eventual abandonment. R. Herbold prepared a card-to-tape, tape-to-printer, tape-to-card, and accounting program to enable the 1410 to serve as a secretary computer for the 7090.
Status of Projects

1102-40-11645/62-1030  ELECTROCARDIOGRAPHIC ANALYSIS
Origin:  NBS, Section 12.5
Sponsor:  Veterans Administration
Manager:  R. J. Herbold
Full Task Description:  April-June 1959, p. 29
Status:  Continued. Statistical analysis runs were continued and results are transmitted to the sponsor. An improved type monitor program is being coded.

1101-12-11416/62-1091  BOUNDS FOR EIGENVALUES
Origin:  Wright Patterson AFB
Manager:  H. Oser
Full Task Description:  October-December 1961 issue, p. 4
Status:  Continued. The attempt to find bounds for eigenvectors has been abandoned. Work on eigenvalue estimates for Legendre's differential equation with nonintegral coefficients continued.

1102-40-11647/62-1125  MATRIX COMPUTATIONS
Origin and Sponsor:  NBS, Section 9.5
Manager:  P. J. Walsh
Full Task Description:  October-December 1961 issue, p. 25
Status:  Terminated. Production runs continued under direction of the sponsor.

1102-40-11647/62-1130  FALLOUT SHELTER COMPUTATIONS
Origin and Sponsor:  Office of Civil Defense
Manager:  D. I. Mittleman
Full Task Description:  October-December 1961 issue, p. 25
Status:  Continued. The calculation of protection factors for all submitted buildings has been completed. Numerous summaries have been prepared and others are in the process of being obtained.

A report summarizing the details of the work performed at the National Bureau of Standards is being prepared.

1102-40-11647/62-1144  THERMAL BOUNDARY LAYERS
Origin and Sponsor:  University of Maryland
Manager:  H. Oser
Full Task Description:  October-December 1961 issue, p. 26
Status:  Terminated. Production runs for both the Blasius case and the forced convection case were completed and the results have been submitted to the sponsor.
Status of Projects

1102-40-11647/62-1155 Mortgage Loan Survey
Origin and Sponsor: Federal Home Loan Bank Board
Manager: Ruth Zucker
Full Task Description: January-March 1962 issue, p. 24
Status: Continued. Three production runs were made for the July and August survey and numerous tables were computed. In addition production runs were made for the ensuing months.

The production run for August involved 96 correlation tables using a survey of 16449 data cards. The data cards were distributed into 3 categories, construction of new homes, purchase of newly-built homes and purchase of previously occupied homes and later sub-divided into the 5 types of lending institutions. The correlation tables also showed the distribution of loans among the 18 selected cities.

The following fields of information, effective interest rate, length of mortgage loan, purchase price of property, per cent of loans to prices were divided into numerous ranges and the per cent of loan distributed in each range was computed.

1102-40-11647/62-1171 Hospital Program Planning
Origin and Sponsor: Veterans Administration, Mount Alto Hospital
Manager: Sally T. Peavy
Full Task Description: January-March 1962 issue, p. 26
Status: Terminated. Production runs continued under direction of sponsor.

1102-40-11647/62-1174 Impulse Calculations
Origin and Sponsor: NBS, Section 30.0
Manager: A. Beam
Full Task Description: January-March 1962 issue, p. 26
Status: Terminated.

1102-40-11647/62-1176 Numerical Integrations
Origin and Sponsor: NBS, Section 15.2
Manager: D. Kaplan
Full Task Description: January-March issue, p. 26
Status: Terminated.
Status of Projects

1102-40-11647/62-1177 ANALYSIS OF VARIANCE
Origin and Sponsor: Diamond Ordnance Fuze Laboratories
Manager: Louis Joseph
Full Task Description: January-March 1962 issue, p. 27
Status: Terminated. Production runs of several complete factorial designs were made. Results were turned over to the sponsor.

1102-40-11647/62-1178 LOGARITHMIC COEFFICIENTS
Origin and Sponsor: NBS, Section 5.3
Manager: R. J. Arms
Full Task Description: January-March 1962 issue, p. 27
Status: Inactive.

1102-40-11647/62-1179 CATALOGUE INFORMATION
Origin and Sponsor: Diamond Ordnance Fuze Laboratories
Manager: Ruth Varner
Full Task Description: January-March 1962 issue, p. 27
Status: Continued. 5007 titles of documents were submitted. Desired was a permuted subject index of the key-word-in-context (KWIC) type. Document titles were altered to conform to the format required to Share distribution 1239. (Bell Labs Permutation Index Program).

Each word in the title was permuted except those words pre-designated in the program as non-significant. The word was cycled to a fixed position in the title and printed out with the corresponding test and document identification number.

The document cards were processed through the code and the permuted subject index submitted to the sponsor.

1102-40-11647/62-1182 FOURIER INTEGRAL
Origin and Sponsor: Diamond Ordnance Fuze Laboratories
Manager: H. Oser
Full Task Description: April-June 1962 issue, p. 25
Status: Continued. Both parts of the program were tested out and found to be quite satisfactory. A program deck was turned over to the sponsor who will conduct the production runs hereafter.
Status of Projects

1102-40-11647/62-1188  STEPWISE REGRESSION
Origin and Sponsor:  Ft. Belvoir, U. S. Army
Manager:  P. J. Walsh
Full Task Description:  April–June 1962 issue, p. 26
Status:  Terminated. The results of the calculation using the SHARE library code are correct. Production runs will be continued under the direction of the sponsor.

1102-40-11647/62-1189  SEQUENTIAL METHODS TABLES
Manager:  R. J. Arms
Full Task Description:  April–June 1962 issue, p. 26
Status:  Continued. Calculations of the confluent hypergeometric function have been successful. The sponsor has received about one half of his desired output.

1102-40-11647/62-1191  CAB TAPE CONVERSION
Origin and Sponsor:  Civil Aeronautics Board
Manager:  G. C. Ziegler
Full Task Description:  April–June 1962 issue, p. 27
Status:  Terminated

1102-40-11647/62-1193  SOLUTION TO SECOND ORDER PARTIAL DIFFERENTIAL ELLIPTIC EQUATION
Origin and Sponsor:  NBS, Section 3.08
Manager:  P. J. Walsh
Full Task Description:  April–June 1962 issue, p. 28
Status:  Continued. Additional test runs are being made. The source function will be introduced under the following condition:

\[
S = \begin{cases} 
1 & \text{for } x^2 + y^2 + z^2 \leq h \alpha \\
0 & \text{for } x^2 + y^2 + z^2 > h \alpha , \text{ where } \alpha \text{ is an input parameter.}
\end{cases}
\]

Several production runs were made using the source function described above.
A third version of the code has been written and checked out.
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This new version solves the problem

$$\nabla^2 \Phi = -ke^{-(x^2+y^2+z^2)} + e^{\Phi}$$

where $k$ and $c$ are input parameters. Some production runs have been made using this equation.

1102-40-11647/62-1196 HEAT OF ADSORPTION
Origin and Sponsor: NBS, Section 15.2
Manager: Ruth Varner
Full Task Description: April–June 1962 issue, p. 29
Status: Continued. The lattice liquid theory of adsorption by Pace has been extended from a three-layer theory to a six layer theory to provide more accurate data in the two to three layer region of multilayer adsorption.

The population ratios, rate of change of population, and differential heats of adsorption for argon on carbon black were determined at 77.7°K. A 7090 code was written to perform far needed calculations. Results were transmitted to the sponsor.

1102-40-11647/62-1201 UHF-TV
Origin and Sponsor: Federal Communications Commission
Manager: W. Hall
Full Task Description: April–June 1962 issue, p. 29
Status: Continued. The program for the original problem has been written and checked. Several production runs have been made on data as it has been forwarded from the field engineers. The analysis of this data have been submitted to the sponsor.

1102-40-11647/62-1202 ANALYSIS OF ION REACTION DATA
Origin and Sponsor: NBS, Section 13.6
Manager: Maxine Rockoff
Full Task Description: April–June 1962 issue, p. 30
Status: Terminated.
Status of Projects

1102-40-11647/62-1203  CYLINDRICAL SHOCK WAVE
Origin and Sponsor:  NBS, Section 3.7
Managers:  Sally Peavy and S. Haber
Full Task Description:  April–June 1962 issue, p. 30
Status:  Continued. Code has been completed and is in the process of being checked out.

1102-40-11647/62-1204  LAPLACE AND FOURIER TRANSFORMS
Origin and Sponsor:  NBS, Section 11.2
Manager:  Maxine Rockoff
Full Task Description:  April–June 1962 issue, p. 31
Status:  Terminated

1102-40-11647/62-1206  CALCULATION OF AVERAGE THEORETICAL DEPRECIATION RESERVES
Origin and Sponsor:  Department of the Treasury
Manager:  R. Herbold
Full Task Description:  April–June 1962 issue, p. 31
Status:  Terminated

1102-40-11647/62-1209  MIXED INITIATION OF DEPOLYMERIZATION
Origin and Sponsor:  NBS, Section 7.6
Manager:  Maxine Rockoff
Full Task Description:  April–June 1962 issue, p. 32
Status:  Terminated. Work under this task will be continued and reported under task 1102-40-11647/58-0266.

1102-40-11647/62-1212  COLOR DIFFERENCES
Origin and Sponsor:  NBS, Section 10.9
Manager:  J. D. Waggoner
Full Task Description:  April–June 1962 issue, p. 33
Status:  Inactive.
Status of Projects

1102-40-11647/63-1218 INTEGRAL EVALUATION

Origin: Diamond Ordnance Fuze Laboratories, Department of the Army
Sponsor: Diamond Ordnance Fuze Laboratories, Department of the Army
Manager: L. Joseph

Objective: To evaluate the following double integral as a function of \( \eta_c \) and \( \omega / \omega_m \):

\[
I = 4 \int_{0}^{\eta_c} d\eta \int_{\pi/2}^{3\pi/2} d\beta \frac{\cos \eta \cos \beta}{\eta + \frac{\omega}{\omega_m} \sin \beta} \left( \sin \eta \sin \beta + 1 \right)^2 \sin^2 \eta
\]

where

\[
0 < \eta_c < \frac{\pi}{2}
\]

and

\[
\frac{\omega}{\omega_m} = \sqrt{\frac{\omega^2}{\omega_m^2} + \frac{\sin^4 \eta}{4} - \frac{\sin^2 \eta}{2}}
\]

Background: The above integral arises in connection with relaxation phenomena for narrow line width ferromagnetic materials.

The use of the substitution \( v = \sin \eta \sin \beta \) reduces the integral to the form:

\[
I = \int_{0}^{\eta_c} d\eta \cos \eta \sin \eta \frac{\sin \eta}{-\sin \eta} \frac{(v + 1)^2}{(1 + \frac{\omega}{\omega_m}) v^2 + 2 \frac{\omega}{\omega_m} v + 1}
\]

The integral with respect to \( v \) can be evaluated in terms of elementary functions. The resulting integral with respect to \( \eta \) can then be evaluated numerically.

The problem was transmitted by G. Jones (DOFL).

Status: NEW. Completed. A program has been written to evaluate the \( \eta \)
Status of Projects

integral using the Simpson's rule. Production runs have been made and results have been given to the sponsor.

1102-40-11746/63-1219 SHOCK TUBE DATA Authorized 6/27/62
Origin: Diamond Ordnance Fuze Laboratories, Department of the Army
Sponsor: Diamond Ordnance Fuze Laboratories, Department of the Army
Manager: L. Joseph
Objective: To process shock tube data in order to determine the half-width of the β line of hydrogen under certain conditions.
Background: The half-width of the curve of intensity, I, versus wavelength λ, is defined to be the difference between the two values of λ for which the intensity is one-half the maximum intensity.
The problem was transmitted by Harry Gieske (DOFL)
Status: New: A computer program was written to process data from a shock tube. The program first fits a minimum distance straight line to certain calibration data. Then this equation is used to transform film density readings to intensity. The half maximum intensity is then obtained by averaging the values of I corresponding to four different values of λ, two of which give maxima and two of which give noise level. The two λ's which yield half maximum intensity are then obtained by linear interpolation.
Production runs have been made and results have been given to the sponsor.

11-2-40-11647/63-1223 CARDIOVASCULAR DYNAMICS Authorized 7/10/62
Origin: Univ. of Pennsylvania, Bockus Research Institute
Sponsor: Univ. of Pennsylvania, Bockus Research Institute
Manager: M. Rockoff
Objective: To develop a computer program which will test the validity of a theoretical model of part of the cardiovascular system.
Background: It is desired to study the manner in which mechanical energy is propagated through the cardiovascular system and how blood volume, flow and pressure are controlled. Techniques have been developed and employed to measure and record pressure and strain in intact living arteries. Also, a theoretical model has been developed which predicts the changes which will occur in an arterial pressure wave as a function of frequency and distance.
The problem was transmitted by Lysle H. Peterson (Univ. of Pennsylvania).
Status: New. The computational aspects of the problem have been analyzed and an outline of a computer program to test the model has been submitted to the sponsor.
Status of Projects

1102-40-11647/63-1228  SHOCK DISSOCIATION  Authorized 7/25/62
Origin:  NBS, Section 3.7
Sponsor:  NBS, Section 3.7
Manager:  A. E. Gregg
Objective:  To obtain shock profiles for nitrogen and for argon containing the dissociating gas, tetrafluorohydrazine \( \text{N}_2\text{F}_4 \), for selected values of the shock Mach number, initial pressure, and mole per cent \( \text{N}_2\text{F}_4 \). The results will provide thermodynamic data for the shocked gas mixtures both at the shock front where no dissociation occurs, and at equilibrium where the dissociation is essentially complete.
Background:  This task is related to an investigation of the reaction kinetics of the \( \text{N}_2\text{F}_4 \) dissociation process carried out by the method of shock wave compression.

The problem was transmitted by H. J. Davis (3.07).
Status:  New. Completed. A program was written to obtain shock profiles for nitrogen and argon containing a dissociating gas tetrafluorohydrazine.
The results provided thermodynamic data for the shocked gas mixtures both at the shock front where no dissociation occurred and at equilibrium where the dissociation was essentially complete.

1102-40-11647/63-1240  SECRET SERVICE FORGERY PROJECT  Authorized 9/10/62
Origin:  Treasury Department, U.S. Secret Service
Sponsor:  Treasury Department, U.S. Secret Service
Manager:  M. Paulsen
Objective:  To provide the Secret Service with information that will expedite and make more efficient and feasible their task of finding and grouping checks signed by the same forger.
Background:  One method of identifying forged government checks was to examine the idiosyncrasies of the signatures. Since the number of forged checks per year added to those on file has become so voluminous this method was no longer efficient or possible. Therefore an idea was conceived whereby all alphabetic and numeric characters and the modus operandi could be classified in such a way that data processing equipment could be utilized to group individuals with respect to their handwriting characteristics.

The problem was transmitted by J. L. Lewis (Treasury Department).
Status:  New. Edit, update, compare and print routines have been written and code checked. No production runs have been made to date.

1102-40-11647/63-1258  SPECTRAL ANALYSIS  Authorized 10/5/62
Origin:  NBS, Section 15.03
Sponsor:  NBS, Section 15.03
Manager:  H. Oser
Status of Projects

Objective: To compute, automatically, all differences $v_i - v_j$ among pairs of bands in molecular spectra; to analyze these differences in terms of their density (differences per interval) and to report significant high density groups of differences. The high density groups and the density per interval information then will be the starting point for the spectroscopic analysis.

Background: Molecular emission spectra generally present a wealth of features, usually not well defined. The analysis of relating the frequencies to the molecular parameters is quite tedious and the use of an electronic computer seems indicated.

The problem was transmitted by David Garvin (15.03).

Status: New. Completed. A Fortran program was written for integral frequencies, but was modified later to accommodate fractional frequencies too. The program is checked out completely and has been turned over to the sponsor who will conduct the production runs.

\[
\begin{align*}
\frac{dt}{d} &= \gamma \left[ \sqrt{D \pi} \right] \tanh \left( \frac{L}{\sqrt{D \pi}} \right) - \sum_{n=0}^{\infty} \frac{2D}{k} \exp \left\{ - \left[ \left( \frac{2n+1}{2} \frac{\pi}{k} \right)^2 D + \frac{1}{\tau} \right] t \right\} \\
&= 0
\end{align*}
\]
Status of Projects

Where \( \gamma, D, T \) are the growth constant, the surface diffusion coefficient and the re-evaporation time respectively. Solutions are discussed for appropriate ranges of parameters. In particular, it is shown under what conditions exponential growth should be observed and that for no re-evaporation:

\[
T \to \infty, \quad \frac{dL}{dt} \to \sqrt{t} \quad \text{for large } t.
\]

The stopping of growth due to surface nucleation is considered.

Background: The data obtained from previous studies in this field (see A, B) will be compared with the results obtained.

References:

The problem was transmitted by R.E. Howard and R.L. Parker(8.05).

Status: New. A Fortran code was written in which the differential equation was solved by the Runge-Kutta method. Results for one set of data were transmitted to the sponsors. This project has been temporarily suspended by the sponsors.

1102-40-11647/63-1275 SECURITIES MARKET STUDY Authorized 11/14/62
Origin: Securities and Exchange Commission
Sponsor: Securities and Exchange Commission
Manager: I. A. Stegun, R. Zucker
Objective: To edit data and prepare various tabulations on securities.
Background: In connection with the special study of the securities markets, information has been obtained regarding specialists and other member activities of the stock exchanges. In order to evaluate this information, it is necessary to have analytical tabulations prepared by the use of a computer. This problem was transmitted by Johnathan Levin (SEC).
Status: New. Editing codes have been written and checked. Tabulation codes are being checked out on small samples.
Status of Projects

1102-30-11647/63-1286  OPTIMAL MEDICAL EXAMINATION SCHEDULE

Origin: Maryland University  Authorized 12/12/62
Sponsor:  Maryland University
Manager:  J. Quinones

Objective: The purpose of this project is to set criteria, and to evaluate policies for medical examinations for preclinically invasive tumors. This is done by the solution of 4 equations with different values for the given sets of parameters.

1) $\epsilon (\Delta, T) = \frac{\lambda}{6} \int_{0}^{\Delta} (A - BS + CX^2 - DX^3) e^{\lambda x} dx$

where $A = \frac{\Delta e^{\lambda \Delta} (e^{2\lambda \Delta} + 4e^{\lambda \Delta} + 1)}{(e^{\lambda \Delta} - 1)^4}$

$B = \frac{3\Delta e^{\lambda \Delta} (1+e^{\lambda \Delta})}{(e^{\lambda \Delta} - 1)^3}$

$C = \frac{3\Delta e^{\lambda \Delta}}{(e^{\lambda \Delta} - 1)^4}$

$D = \frac{1}{(e^{\lambda \Delta} - 1)}$

$\lambda = 0.2 \quad \Delta = 1 \quad T = 0.1 (.1) .9$

$\lambda = 0.2 \quad \Delta = 1 \quad T = 0.2 (.2)1.8$

2) $\epsilon(\Delta, T) = \epsilon, (\Delta, T) + \frac{\lambda}{6} \int_{0}^{T} e^{-3y} e^{\lambda y} (A - By + Cy^2 - Dy^3) dy$

with parameters same as in 1)

3) $\frac{G_4(X_{k+1} - T) - G_4(X_k)}{G_4(X_{k+1}) - G_4(X_k)} = \epsilon$

where $G_4(X) = e^{-x} (1 + X + \frac{X^2}{2!} + \frac{X^3}{3!} + \frac{X^4}{4!})$

$X_0 = 0, X_k \geq 60; \lambda = 0.2; T = 0.1, 0.5; \epsilon = 0.05, 0.1, 0.2$
Status of Projects

4) \[ X_{k+1} \left[ G_4(X_k) - G_4(X_{k+1}) \right] - \frac{4}{\lambda} \left[ W(X_k) - W(X_{k+1}) \right] = T \]

where \( G_4(X) = e^{-X} \left( 1 + X + \frac{X^2}{2} + \frac{X^3}{3!} + \frac{X^4}{4!} \right) \), \( W(X) = e^{-\lambda X} \left( \frac{1}{2} \frac{(\lambda X)^2}{2} + \frac{(\lambda X)^3}{6} + \frac{(\lambda X)^4}{24} \right) \)

\[ X_0 = 0, X_k \leq 60; \quad \lambda = 0.2; \quad T = 0.25, 0.5, 0.75 \]

Background: It is assumed that a possibility of misdiagnosis exists which is a decreasing function of the time since inception of the disease. The simplest policy is periodic with period \( \Delta \). If it is assumed that diagnosis is perfect, and that the probability density for incidence is:

\[ U(t) = \frac{\lambda^4}{6} t^3 e^{-\lambda t} \]

then the probability that a tumor will go undetected for a time \( T \) or greater is given by equation 1).

If the probability of misdiagnosis is taken to be \( e^{-3t} \), then the probability for a tumor to remain undetected for a time \( T \) or greater is given by equation 2).

Finally, the optimum schedule of examination times \( t_1, t_2, \ldots \), given a desired level of protection \( \epsilon \), is given by equations 3) and 4).

The problem was transmitted by George H. Weiss (Maryland University).

Status: New. Three Fortran codes were written, productions runs were made and the answers were transmitted to the sponsor. Completed.
7. STATISTICAL ENGINEERING SERVICES

COLLABORATION OF STATISTICAL ASPECTS OF NBS RESEARCH AND TESTING

Task 3911-61-39951/51-1

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

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

(i) Joan R. Rosenblatt continued to collaborate with G. L. Howett of the Photometry and Colorimetry Section on statistical aspects of the experimental program of the Committee on Uniform Color Scales of the Optical Society of America.

(ii) A study of the behavior of measurements from the calibration of mercury in glass thermometers was begun by Dr. Eisenhart and Janace Speckman in cooperation with Mrs. Massie of the Temperature Physics section. The purpose of the study is to ascertain from a detailed statistical analysis of several years data whether there is evidence of non-homogeneity of variance or any other such phenomena that might affect the precision and accuracy of the process.

(iii) George Weiss is collaborating with M. M. Siddiqui (NBS Boulder Laboratories) in work on a distribution function for received radio signals through a medium in which scattering is significant.

(iv) Collaboration with the Mass and Scales Section continued with work being carried on in the preparation of a program for automatic calculation of results of calibration.

(v) Work was begun by W. J. Youden on the construction of classes of paired designs for use in calibrations. As an example, items A, B, C, D, E, and F are calibrated against a standard S, by making the 9 comparisons given by the line segments in the diagram, i.e., by AB, BC, AS, CS, SE, etc.

All comparisons with the standard have the same precision. Wear on the standard is minimized because B and D are calibrated indirectly.

Publications:

(1) On the realistic measurement of precision and accuracy. Churchill Eisenhart. ISA Proceedings of the Eighth National Aero-Space
Status of Projects

Instrumentation Symposium, held in Washington, May 1962, pp. 75-83.


(6) Mean first passage times and the dissociation of diatomic molecules. Kurt Shuler (Institute for Defense Analysis) and George Weiss. Submitted to the Journal of Chemical Physics.

STATISTICAL SERVICES
Task 1103-40-11625/58-346

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

Status: INACTIVE.
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This is a record of the use of the IBM 7090 for the period of July 1 through December 31, 1962.

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Totals (NON-NBS Services) 2025 9614 34949 46588

TOTAL TIME FOR THE QUARTER (MINUTES) 4044 20797 43373 68214
Current Applications of Automatic Computer

+ Problem programmed in the Computation Laboratory, production runs continued under direction of sponsor.

++ Problem programmed by the sponsor and run under his direction.

+++ Functions pertain to the internal operations of the Computation Laboratory.

++++ Classified task.
Lectures and Technical Meetings

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.

Applied Mathematics Division Lectures


Seminar in Mathematics

A series of weekly seminars led by Dr. Seymour Haber with the cooperation of Dr. Oved Shisha, was conducted to cover the Princeton lecture notes, "Advanced Calculus" by H. K. Nickerson, D. C. Spencer, and N. E. Steenrod (D. Van Nostrand Co., 1959). July-December 1962.
Lectures and Technical Meetings

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


BERNSTEIN, B. Some researches in finite visco-elastic deformation. University of Delaware, Newark, Delaware, Nov. 21, 1962.


TCHEN, C. M. (i) Kinetic equations of plasmas. Presented at the Aero-Space Corporation, Los Angeles, California, December 10, 1962. (ii) Interaction of the solar corpuscular stream with the Geomagnetic Field and Landau damping with collective correlations, Presented at the Jet Propulsion Laboratory, California Inst. of
Lectures and Technical Meetings


VINTI, J. P. Some ideas about satellite orbits, with application to the space program. Presented at Georgetown University, Washington, D.C., November 19, 1962.


Lectures and Technical Meetings


Publication Activities

1. PUBLICATIONS THAT APPEARED DURING THE PERIOD
   July - December, 1962.

1.2 Technical Notes, Manuals, and Bibliographies


Selected bibliography of statistical literature, 1930 to 1957: VI

1.3 Technical Papers

Safety levels in military inventory management. F. L. Alt.


Conditions for second order waves in hypo-elasticity. B. Bernstein.

A connection between Tauberian theorems and normal functions.


Roger Joseph Boscovich and the combination of observations.

Publication Activities


An application of information theory to the analysis of contingency tables, with a table of $2^n$, $f_n$, $n$, $n = 1(1) 10,000$. S. Kullback (George Washington University), M. Kupperman (George Washington University), and H. H. Ku, Journal of Research, NBS, 66B, No. 4, 1962, 217-243.


Publication Activities


Publication Activities


2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION

2.1 Mathematical Tables


2.3 Technical Papers


Ferroelectric switching and the Sievert integral. P. H. Fang (Physical Properties Section) and Irene A. Stegun. Submitted to a technical journal

Publication Activities


Precision of simultaneous measurement procedures. W. A. Thompson, Jr. Submitted to a technical journal.

On the rank sum test for outliers. W. A. Thompson, Jr. and T. A. Willke. Submitted to a technical journal.


Publication Activities

Linear operations on matrices. M. Marcus. In manuscript.


Error bounds for first approximations in turning-point problems. F. W. J. Olver. Submitted to a technical journal.

Error bounds for asymptotic expansions in turning-point problems. F. W. J. Olver. In manuscript.

Error analysis of Miller's recurrence algorithm. F. W. J. Olver. In manuscript.


Publication Activities


Pointwise bounds in the first biharmonic boundary value problem.
THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.


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BOULDER, COLO.


CENTRAL RADIO PROPAGATION LABORATORY


RADIO STANDARDS LABORATORY


U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Assin, Director

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