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CONTENTS

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WHEN LINES ARE POINTS[1]

by Harry Levy

The beginning student derives a great deal of pleasure from working in mathematics. In part his sense of satisfaction stems from his realization that mathematical problems have a definiteness that problems in other areas often seem to lack, and that the correctness, or lack of it, of his solutions is not a matter of opinion but a hard mathematical fact. It may therefore be surprising to some of you when I observe that mathematics resembles the fine arts and indeed may be called one of them; it does so because the mathematician like the poet, the sculptor, and the composer, creates something out of nothing using only his talent and his knowledge, the resources of his intellect. This may have been the frame of mind that led the youthful geometer Janos Bolyai to write to his father, in 1823, "I have created a new universe out of nothing." Like all great artists, Bolyai was passionately proud of his creation, and like all great art, Bolyai's work is immortal. It lives on in today's nuclear age to which it has been bound by the work of Lobachevski and Gauss, of Riemann and Ricci, of Einstein, and of many others.

But the artistry of mathematics is only one of its aspects. Mathematics is a science, because mathematicians observe and study existing mathematical structures, and discover and formulate the basic principles that govern them. Perhaps one characteristic that distinguishes mathematics from other areas of human endeavor is that the scientific side of mathematics and its artistic side are united in one coherent whole; I intend this evening to suggest how Riemann, a great German mathematician of the middle nineteenth century, might have been led to the creation of elliptic geometry (one of the two classical non-Euclidean geometries) by a "scientific" study of a particular Euclidean structure.

Before going on to my main objective, I should like to note that when a scientist is confronted with something apparently new, he frequently uses the method of analogy. He compares the new with the familiar, and, drawing on his knowledge of the latter, he is often able to direct his studies in a meaningful way. In using this method in mathematics, proper vocabulary and suitable choice of symbols can serve to illuminate the structure being studied and to clarify the problems whose solution is being sought. The primitive elements of geometry are usually called points, and when a mathematician is investigating any kind of mathematical structure by geometrical methods, he is very likely to call the constituent elements of his structure points, even though, in some other context, he may refer to them as lines, or functions, or matrices, or spheres, or transformations.

The structure that we propose to investigate is a bundle of lines in ordinary, that is, Euclidean (three-dimensional) space. For our purposes, a bundle of lines means the set of all lines through a given point. Some

[1] **These remarks were presented to the Undergraduate Mathematics Club, University of Illinois, Urbana, Illinois.**

of you may wonder whether such a commonplace structure can possess any exciting properties. Since we wish to examine relationships between lines of the bundle, since our "space", that is, the bundle, is a set of lines, it is clear that we are to be concerned with a geometrical analysis in which the primitive elements are lines. However strange it may seem, we cannot hesitate. From this moment on, whenever we speak of a ***point*** we shall mean a ***line*** of the given bundle. We formalize this first step of our analysis thus:

1. There exists a set of objects called points; their totality, together with the relationships between them, is called an elliptic plane.

We shall denote the elliptic plane by E_2, and the notation $X \in E_2$ is read "X is an element of E_2", that is, X is a point of the elliptic plane. To prove a theorem in elliptic geometry, it suffices for our purpose to select a suitable theorem about lines of a bundle and then translate the relationships involving lines of the bundle into geometrical language appropriate to the elliptic plane. In the bundle of lines, each two lines determine a real number, their angle, which we can, for convenience, measure in right-angle units. We commented earlier on the importance of vocabulary; what shall we call this number when we are concerned with elliptic geometry? It would seem that the word "distance" might prove useful; using this terminology enables us to put our second observation of elliptic geometry as follows:

2. Each two points of E_2 determine a real number; if $P, Q \in E_2$, we call the number they determine the (elliptic) distance between them, and we denote it by $e(P, Q)$. We call e the distance function or the metric of E2; it satisfies the following conditions:

(a) $0 \leqq e(P, Q) = e(Q, P) \leqq 1$;

(b) $e(P, Q) = 0$ **if and only if** $P = Q$;

(c) $e(P, R) \leqq e(P, Q) + e(Q, R)$.

The proof of (a) and (b) is indeed trivial; (c) can be established by elementary solid analytic geometry if we introduce rectangular coordinates chosen so that the direction cosines of the lines representing Q, P, R are $(1,0,0)$, $(\cos\phi, \sin\phi, 0)$, $(\cos\alpha, \cos\beta, \cos\gamma)$, respectively, where $\cos\phi \geqq 0$, $\cos\alpha \geqq 0$.

The Euclidean distance function satisfies these three conditions with the exception of the second inequality in (a), and indeed these conditions play an important role in defining metric geometries that are more general than either Euclidean or elliptic. The last inequality in (a) tells us that in elliptic geometry, as in spherical geometry, distance is bonded. Condition (c) is called the triangle inequality; it can be used to define the curves that play the role of Euclidean straight lines. But even in elliptic geometry there are difficulties that we need to take care of. Returning to our bundle of lines, we see that $\angle PQ + \angle QR = \angle PR$, where P, Q, R are lines, if and only if Q is coplanar with P and R and lies in the acute angle sector formed by them. But we would like to prolong an elliptic line beyond any one of its points, and we can be satisfied with the following formulation:

3. If P, Q are distinct points of E_2, there exists one (and just one) point P^*_Q such that

$$e(P, Q) + e(Q, P^*_Q) = e(P, P^*_Q) = 1.$$

We define the elliptic line through P and Q to consist of all points X such that

$$e(P, X) + e(X, P^*_Q) = e(P, P^*_Q).$$

Circles arise naturally in any two-dimensional metric geometry.

4. If $P \in E_2$, and r is a positive real number, the (elliptic) circle with center P and radius r is the set of points X distant r from P, $e(P, X) = r$.

Thus an elliptic line corresponds to a pencil in the Euclidean bundle, and an elliptic circle to a circular cone (with one exception)

We now have points, lines, circles, and distance in our emerging geometry. Do these concepts differ significantly from their Euclidean counterparts? If we turn to elementary intersection and incidence relations, we find some results that are ordinary, and others that deviate sharply from the Euclidean pattern.

(A) Two distinct points in E_2 are incident to (that is, lie on) exactly one line.

(B) Two distinct lines in E_2 have exactly one point of intersection. Thus the phenomenon of parallel lines does not exist in E_2.

(C) Every line in E_2 is a circle of radius one. Here we have a property that suggests spherical geometry, but the parallelism is not complete since every circle in spherical geometry has two centers.

(D) Concurrent lines in E_2 have collinear centers, and lines with collinear centers are concurrent:

A somewhat less elementary property of elliptic lines is the following:

(E) Every line in E_2 is a simple closed curve of length two.

A Euclidean line is cut when one of its points is deleted, and the two portions form the two rays emanating from the point. Removal of one point of an elliptic line leaves the line connected; to cut the line two points must be removed, and of the two segments then formed, one has length equal to the distance between the deleted points, and the other, two decreased by that distance. But a more interesting situation arises when we examine (E) and (B) together. We are doomed to fail if we attempt to portray these two properties on a blackborad. Have we found a contradiction? No, the validity of (E) and (B) is irrefutable. We may have gone astry in tacitly supposing that in every two-dimensional geometry a simple closed curve determines an exterior and an interior. We need only to consider on a torus either a generating circle or a parallel circle to see the error in such an assumption.

Let us return to our model, the bundle of lines. Let p be a pencil of lines in the bundle, and let P and Q be any two distinct lines not in p. Then clearly the pencil determined by P and Q is separated by P and Q into two sectors of lines, one of which has a line in common with p, and the other does not. Thus, in E_2, any two points not on a given line of E_2 can be joined by a segment which does not intersect the given line. If E_2 were cut along the given line, it would remain connected. We thus have the following:

(F) An elliptic line is a nonbounding curve.

There is one farther very fundamental difference between the elliptic plane and the Euclidean plane. The latter is orientable, and it possesses two orientations. A line reflection interchanges the two orientations, whereas rotations and translations preserve both orientations.

Thus an orientation-preserving motion in the Euclidean plane can never be the product of an odd number of line reflections. We cannot here prove that E_2 (like the Mobius band) is nonorientable, but we can prove that the Euclidean distinction between products of an odd and of an even number of line reflections has no significance in E_2.

A point reflection in Euclidean space leaves fixed each line of the bundle through the point; it therefore acts as the identity transformation when interpreted in E2. On the other hand, it is the product of successive reflections in three mutually orthogonal planes. A reflection in a plane when interpreted in E_2 becomes a reflection in a line (the elliptic line corresponding to the pencil in the plane). Thus in E_2 the product of three line reflections can be the identity, so that the product of two line reflections can be a sinele line reflection.

Those of you who mightwish to follow up these preliminary remarks on elliptic geometry could investigate one or more of the following problems:

(a) The problem of coordinatization. One way to establish coordinates in E_2 is to represent a point by direction numbers of the corresponding line of the bundle.

(b) The problem of axioms. It is possible to establish a system of axioms which give E_2 a logical existence independent of Euclidean space.

(c) The development of relationships between an elliptic and a Euclidean plane. Such a development can create for the Euclidean plane a unity which would otherwise be lacking. For example, all "conies" in E_2 are closed curves, and by means of them we can find common properties of conics in the Euclidean plane.

University of Illinois

CONFORMALLY ELEMENTARY POINTS[1]

By Louis E. De Noya
Oklahoma Beta

INTRODUCTION

In 1953 Professors Peter Scherk and N. D. Lane published a paper (3) which employed unique methods for the study of conformal differential geometry; methods which are rather synthetic in character. If we consider the conformal plane as the one point compactification of the Euclidean plane it is apparent that methods from complex variables might be used in its study. However, certain desired properties are lost when extensions to conformal spaces of higher dimensions are attempted. The methods of Scherk and Lane are directly applicable to higher spaces (2, 5, 7). They are related to methods developed by Scherk in his studies of projective spaces (6).

The results presented in this paper are due primarily to these two men. Some of their work has been modified and new proofs have been offered for particular theorems by both the present writer in his master's report (1) and by F. A. Sherk in his master's thesis (7). The introduction of conformally elementary points and an indication of their use are our goals.

PRELIMINARIES

The points studied here are considered to be interior points of real arcs embedded in the conformal plane. This restriction to interior points is one of convenience for the theory has also been developed to emcompass end points of arcs.

A proper circle C will decompose the plane into two regions, the interior C_* and the exterior C^* of C. The interior lies to the left of the orientation of C. The infinite sequence of circles $C_1, C_2, \ldots$ will converge to the circle C if there exists to every pair $C' \subset C$ and $C'' \subset C$ an integer $k = k(C', C'')$ such that $C' \subset C_{n*}$ and $C'' \subset C_n^*$ for every integer $n > k$. Convergence of a sequence of points to a point and convergence of a sequence of circles to a point are defined similarly. It will be convenient to denote by $C(P, Q, R)$ the circle C drawn through the three mutually distinct points P, Q and R. $C(\pi P)$ will denote the circle C of the linear pencil π of circles which passes through the point P. Only pencils of the second kind with fundamental point s will be considered (cf. Fig. 1).

Finally, suppose that s is an interior point of an arc A. Then s is called a point of support (intersection) with respect to a given circle C if there

[1] Received by Editors September 30, 1961. Presented at the National Meeting of Pi Mu Epsilon, Stillwater, Oklahoma, August 29, 1961. This paper was judged best for graduate students. Mr. De Noya won a hundred dollar prize.

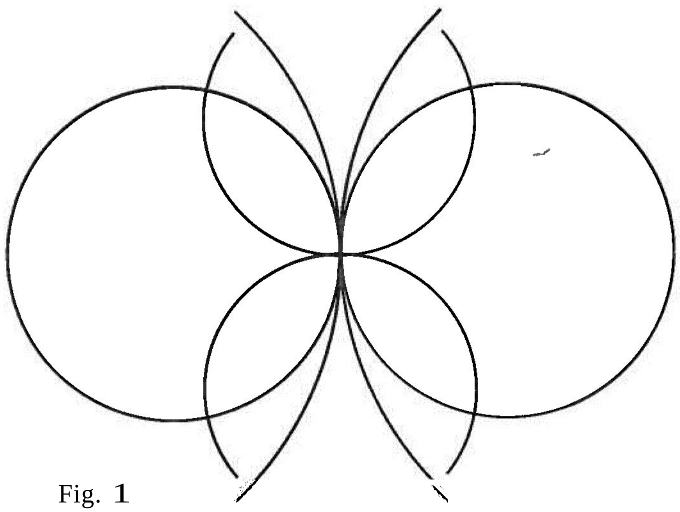

Fig. 1

is some neighborhood of **s** decomposed by **s** into two open neighborhoods which lie in the same (different) regions bounded by C. C is termed a supporting (intersecting) circle of A at **s.** By definition the point circle **s** supports A at **s.** It may be that for a given arc there are points of the arc which are neither points of support nor of intersection, **e.g.** the arc $t \sin \frac{1}{t}$ at t = 0.

DIFFERENTIABILITY

We shall say that an arc A is differentiable at an interior point **s** (or that **s** is a differentiable point) if two conditions are satisfied. The f i t of which is $t \sin \frac{1}{t}$ at $t = 0$.

Condition I.

Let $s \subset A$. Then for every point $P \neq s$ and for every sequence of distinct points $\{\bar{s}\} \to s$, such that each $\bar{s} \subset A$, there exists a circle C_o such that $C(\bar{s}, s, P) \to C_o$.

The circle C_o is called the tangent circle of A at **s** and is clearly independent **of how** $\{\bar{s}\}$ converges. However, C_o does depend continuously upon P. The point s is itself the tangent point-circle of A at **s.**

Theorem 1

The set $\tau = \tau(s)$ of all tangent circles of A at **s** is a pencil of the second kind with fundamental point **s.**

Proof. Let P, Q **and** R be three mutually distinct points. If the sequence of points $\{\bar{R}\} \to R$, $\bar{R} \neq R$, **then** the angle **between** the circles of the sequence of circles $C(\bar{R}, R, P)$ and $C(\bar{R}, R, Q)$ converges to zero. Thus, the circles have (in the limit) the one **point** $\underline{R}$ in common and are **therefore** tangent. Suppose now that $R = s$ and $\bar{R} = \bar{s}$, where $s \subset A$ and $\bar{s} \subset A$, then

$$\lim_{\bar{s} \to s} \measuredangle\, [C(\bar{s}, s, P); C(\bar{s}, s, Q)] = 0$$

Since the only restriction placed upon the points P and Q was that they be distinct it follows that for every other distinct point M there is one and only one circle through M and tangent to A at **s.** Hence, if two tangent circles have another point in common they must be identical. Moreover, let some circle C touch the tangent circle C_o at **s** and let $P \subset C$, $P \neq s$. Then C_o and C are identical, **i.e.** $C \subset \tau$. Therefore the totality of tangent circles of A at **s** constitutes a pencil $\tau = \tau(s)$ of the second kind with fundamental point **s.**

Corollary

If $C(\tau, P)$ and $C(\tau, Q)$ have another point in common they are **identical.** Thus, there is one ond only one circle of T through each point $P \neq s$.

The above then yields

Theorem 2.

Suppose that the point $s \subset A$ satisfies Condition I. Let π be a pencil of the second kind with fundamental point $s, \pi \neq \tau$. If $\{\bar{s}\} \to s$ ($\bar{s} \subset A$, $\bar{s} \neq s$), then

$$\lim_{\bar{s} \to s} C(\pi, \bar{s}) = s.$$

Theorem 3.

Let **s** be an interior point of an arc A and assume that **s** satisfies Condition I. Then every non-tangent circle either supports or intersects A at **s.**

Proof. Suppose that C neither supports nor intersects A at **s.** Then the non-support supposition implies that there is a sequence of distinct points $\{\bar{s}\} \to s$ **such that** $\bar{s} \subset (A \cap C)$ **and** $\bar{s} \neq s$. **Now let** $P \subset C$, $P \neq s$. Then $C = C(\bar{s}, s, P)$ for every $\bar{s} \neq s$.

But Condition I implies that $C = C(\tau, P)$ which contradicts the hypothesis C was a non-tangent circle. Therefore our supposition was false and the theorem is proved.

Condition II.

If $\{\bar{s}\} \to s, \bar{s} \neq s$, then $C(\tau, \bar{s})$ converges to some unique circle $C(s)$. $C(s)$ is the osculating circle at **s.**

The arc A is differentiable at **s** if both conditions I and **II** are satisfied. It can be shown that the two conditions are independent (1, 3, 7).

The following three theorems deal with non-osculating circles. It will be noted that they, together with the preceding theorem, provide us with a complete classification of distinct types of differentiable points.

Theorem 4.

Let **s** be a differentiable interior point of an arc A. Then every **non-**osculating circle either supports or intersects A at **s.**

The proof of this theorem is similiar to that of Theorem 3 and will be omitted.

Theorem 5.

If the osculating circle $C(s)$ is different from the point circle s, then every non-osculating tangent circle supports A at s.

Proof. Let C be any proper non-osculating tangent circle of A at s, i.e. $C \subset \tau$. Then by Theorem 4 C either supports or intersects A at s. Suppose that C intersects. If a sequence of points $\{\bar{s}\}$ exists such that $\bar{s} \subset (A \cap C^*)$, $\bar{s} \neq s$, $\{\bar{s}\} \to s$, then each $C(\tau, \bar{s})$ lies in the closure of C^*. Hence, by Theorem 1 we have $C(\tau, \bar{s}) \subset C^* \cup s$ and $\{\bar{s}\} \to s$ gives us

$$C(s) \subset (C^* \cup C)$$

Now similiar consideration a sequence $\{\bar{s}_1\} \subset (A \cap c^*)$ with $\bar{s}_1 \neq s$, $\{\bar{s}_1\} \to s$ gives us that

$$C(s) \subset (C_* \cup C)$$

By combining $C(s) \subset (C^* \cup C)$ and $C(s) \subset (C_* \cup C)$ we have that $C(s) = C$, which contradicts the hypothesis. Thus, C supports A at s.

We now consider the final case, when the osculating circle $C(s)$ is the point circle s. The proof follows from the above.

Theorem 6.

If $C(s) = s$, then the non-osculating tangent circles at s either all support or all intersect A at s.

CHARACTERISTIC

We now introduce the important concept of the characteristic of a differentiable point. It is not our purpose to exhibit the reasoning behind the definition but to indicate how by using it we may classify differentiable points.

The characteristic (a_0, a_1, a_2, i) has the following properties

$$i = 1 \text{ or } 2$$
$$a_0 = 1 \text{ or } 2$$
$$a_1 = 1 \text{ or } 2$$
$$a_2 = 1, 2 \text{ or } \infty$$

$i = 1$ if $C(s) \neq s$; $i = 2$ if $C(s) = s$. The number a_0 is even or odd as the non-tangent circles through s intersect or support; $a_0 + a_1$ is even or odd as the non-osculating tangent circles support or intersect; $a_0 + a_1 + a_2$ is even if $C(s)$ supports, odd if $C(s)$ intersects, while $a_2 = \infty$ if $C(s)$ neither supports nor intersects.

Theorem 5 places a restriction upon the characteristic in that if $C(2) = s$, $i = 1$ and $a_0 + a_1$ is even. Moreover, the agreement that the point-circle always supports implies that $a_0 + a_1 + a_2$ is even. With these restrictions in mind it is seen that there exists ten distinct types of differentiable points in the conformal plane (1, 3, 7).

ORDER

An arc A in the conformal plane is said to be of finite cyclic order if it has only a finite number of points in common with any circle. If some circle C meets **A** n times and no circle meets **A** more than n times where n is a specific integer, then **A** is said to be of bounded cyclic order and n is called the (cyclic) order of A. If s is any point on A, the order of **s** is the minimum of the orders of all neighborhoods of **s** on **A.** In this note we shall deal only with arcs of order three. However, the next theorem, which will in part justify our choice for the characteristic, does not specify the order of the arc and yet does concern the order of a point on this arc.

Theorem 6.

Let **s** be a differentiable interior point of the arc A. Suppose that s has the characteristic $(a_0, a_1, a_2; i)$. Then the order of **s** is not less than $a_0 + a_1 + a_2$.

The proof of this theorem is too long to include here. We have listed it because we shall indicate how it can be sharpened when **s** is conformally elementary.

Suppose now that we have three mutually distinct points u, v, q such that u and v converge on an arc A to a point s and that

$$\lim C(u, v, q) = C.$$

Then C is termed a general tangent circle of A at **s.** Moreover if q also converges to **s,** then C is a general osculating circle of A at **s.** We say that A is strongly differentiable at **s** if the following two conditions are met.

Condition I'. Let $R \neq s$, $q \to R$. If two points u and v converge on A to **s,** then $C(u, v, q)$ always converges.

Condition II'. $C(t, u, v)$ converges if the three mutually distinct points t, u, v converge on A to **s.**

It can be shown that strong differentiability implies ordinary differentiability and that $C(s)$ is the one and only osculating circle, for if in I' we let $Q = R$ and $u = s$ we have that I' implies I and

$$\lim C(u, v, q) = C(\tau, R).$$

Condition II' and II are similarly related.

Elementary Points. We now have sufficient background for the introduction of conformally elementary points. We say that a point s of an arc A is conformally elementary is there exists a neighborhood of s decomposed by s into two neighborhoods of order three. It has been shown (4, 6, 7) that their closures are strongly differentiable at **s.** Theorem 6 can now be made more exact.

Theorem 6'

Let **s** be a differentiable **conformally** elementary point with characteristic $(a_0, a_1, a_2; i)$, then the cyclic order of **s** is precisely $a_0 + a_1 + a_2$.

It is, of course, much more satisfactory to deal with an equality rather than an inequality as in Theorem 6.

We have indicated that strong differentiability implies ordinary differentiability. The converse is not true. However, if the differentiable point is conformally elementary we have

Theorem 7

Suppose that s is a conformally elementary **point-on** the arc A. Then

i) s satisfies Condition I' if and only if it satisfies Condition I and $a_0 = 1$ (i.e. if the non tangent circles through s support),

ii) A is strongly differentiable at s if and only if it is differentiable at s and $a_0 = a_1 = 1$.

Besides providing a useful link between ordinary and strong differentiability confonnally elementary points are used with much success in the study of vertices of closed curves in the conformal plane. Finally, they are instrumental in supplying a conformal proof of the Four Vertex Theorem. The study of conformally elementary points does not belong in an introduction to conformal differential geometry. These points are used to unify certain preliminary results and to give order and meaning to more extensive and more profitable studies. It has been this author's expressed purpose to provide the material necessary for their introduction and to indicate how some of this material is further related.

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Oklahoma State University

GENERAL SOLUTION TO THE LINEAR DIOPHANTINE EQUATION IN TWO VARIABLES[1]

By T. W. Shook
Ohio Alpha

INTRODUCTION

It is well known that the Diophantine equation

$$ax + by = c \quad \text{------------------------} \quad (1)$$

has integer solutions if and only if **(a,b,)/c,** in which case the general solution is given by:

$$x = x_0 + \frac{b}{(a,b)}\, t$$

$$y = y_0 - \frac{a}{(a,b)}\, t$$

$$(t = 0, \pm 1, \pm 2, \ldots) \quad \text{------------------} \quad (2)$$

where x_0 and y_0 are a solution to equation 1.

Normally, the initial solution is found by an algorithm which is often lengthly and cumbersome. This paper expresses x and y directly as a function of a, b, and c, eliminating the algorithm altogether.

THE GENERAL SOLUTION

Suppose a and b are two integers with $0 < a \leq b$. We define a sequence of remainders recursively as follows:

$$\langle ab \rangle_0 = b$$

$$\langle ab \rangle_1 = a$$

$$\langle ab \rangle_{k+1} = \langle ab \rangle_{k-1} - \langle ab \rangle_k \cdot \left[\frac{\langle a,b \rangle_{k-1}}{\langle a,b \rangle_k} \right]$$

$$(k = 1, \ldots, \lceil ab \rceil - 1) \quad \text{--------------} \quad (3)$$

WHERE:

$$\lceil ab \rceil = \text{MAX} \left\{ k \mid \langle ab \rangle_k > 0 \right\} \quad \text{------------} \quad (4)$$

THEN DEFINE:

$$\boldsymbol{\langle} ab \boldsymbol{\rangle} = b\,(a,b) \sum_{j=0}^{\lceil ab \rceil - 1} \frac{(-1)^j}{\langle ab \rangle_j \langle ab \rangle_{j+1}}$$

$$\langle\!\langle ab \rangle\!\rangle = -a\,(a,b) \sum_{j=1}^{\lceil ab \rceil - 1} \frac{(-1)^j}{\langle ab \rangle_j \langle ab \rangle_{j+1}} \quad \text{--------} \quad (5)$$

The following theorem then gives **the general solution:**

THEOREM - Given the Diophantine Equation

$$ax + by = c \quad \text{------------------------} \quad (1)$$

1 Received by Editors October 11, 1961. Presented at the National Meeting of Pi Mu Epsilon, Stillwater, Oklahoma, August 29, 1961. This paper was judged best for undergraduates. Mr. Shook won a hundred dollars prize.

One may assume without loss of generality that $0 < a \leq b$. Then (1) is solvable if and only if $(a,b) \mid c$, in which case the general solution is:

$$x = \frac{c\langle ab\rangle}{(a,b)} + \frac{bt}{(a,b)} \qquad y = \frac{c\langle\!\langle ab\rangle\!\rangle}{(a,b)} - \frac{at}{(a,b)}$$

$$t = 0, \pm 1, \pm 2, \ldots \qquad \text{-------------------(6)}$$

PROOF – We need only show that $\langle ab\rangle$ and $\langle\!\langle ab\rangle\!\rangle$ are integers satisfying

$$a\langle ab\rangle + b\langle\!\langle ab\rangle\!\rangle\ 1 = (a,b) \qquad \text{-------------------(7)}$$

If one substitutes the values given in (5) for $\langle ab\rangle$ and $\langle\!\langle ab\rangle\!\rangle$, equation (7) becomes a trivial identity.

We prove that $\langle ab\rangle$ and $\langle\!\langle ab\rangle\!\rangle$ are integers by induction on $\lceil ab \rceil$.

α) When $\lceil ab \rceil = 1$, $a \mid b$ and $(a,b) = a$. The Formula (5) yields $\langle ab\rangle = 1$ and $\langle\!\langle ab\rangle\!\rangle = 0$.

β) Suppose $\lceil ab \rceil = k > 1$ and let $r = \langle ab\rangle_2$. Then $\lceil ra \rceil = k-1$ so $\langle ra\rangle$ and $\langle\!\langle ra\rangle\!\rangle$ will be integers by the induction hypothesis.

Also note that $\langle ab\rangle_j = \langle ra\rangle_{j+1}$ and $(r,a) = (a,b)$. Then

$$\langle\!\langle ab\rangle\!\rangle = -a\,(a,b) \sum_{j=1}^{k-1} \frac{(-1)^j}{\langle ab\rangle_j \langle ab\rangle_{j+1}}$$

$$= a\,(r,a) \sum_{j=1}^{(k-1)-1} \frac{(-1)}{\langle ra\rangle_j \langle ra\rangle_{j+1}} \quad \langle ra\rangle, \text{ an integer.}$$

Solving Equation (7) for $\langle ab\rangle$,

$$\langle ab\rangle = \frac{(a,b) - b\langle\!\langle ab\rangle\!\rangle}{a} = -\left[\frac{b}{a}\right]\langle\!\langle ab\rangle\!\rangle + \frac{(a,b) - r\langle\!\langle ab\rangle\!\rangle}{a}$$

The right-hand term of the above expression is

$$\frac{(a,b) - r\langle\!\langle ab\rangle\!\rangle}{a} = \frac{(r,a) - r\langle ra\rangle}{a} = \langle\!\langle ra\rangle\!\rangle, \text{ which is an integer.}$$

Hence $\langle ab\rangle$ and $\langle\!\langle ab\rangle\!\rangle$ are integers. This completes the proof.

Ohio State University

PROBLEM DEPARTMENT

Edited by
M. S. KLAMKIN
State University of New York
at Buffalo

This department welcomes problems believed to be new and, as a rule, demanding no greater ability in problem solving than that of the average member of the Fraternity, but occasionally we shall publish problems that should challenge the ability of the advanced undergraduate and/or candidate for the Master's Degree. Solutions of these problems should be submitted on separate, signed sheets within four months after publication. Address all communications concerning problems to M. S. Klamkin, Division of Interdisciplinary Studies and Research, State University of New York at Buffalo, Buffalo 14, New York.

PROBLEMS FOR SOLUTION

144. Proposed by **Hüseyin Demir, Kandilli,** Eregli, **Kdz.,** Turkey.
Find the shape of a curve of length L lying in a vertical plane and having its end points fixed in the plane, such that when it revolves about a fixed vertical line in the plane, generates a volume which when filled with water shall be emptied in a minimum of time through an orifice of given area A at the bottom. (Note: The proposer has only obtained the differential equation of the curve.)

145. Proposed by David L. **Silverman,** Beverly Hills, California.
For what integers a and b $(0<a<b)$ are the roots of
$$x^4 + (a+b)x^3 + (a+b+ab)x^2 + (a^2+b^2)x + ab = 0,$$
integers?

146. Proposed by C. W. Trigg, **Los** Angeles City College.
Find a set of three-digit numbers, each of which is a permutation of the same three digits, which when divided by the sum of the digits yields two pairs of alternate integers.

147. Proposed by Leo **Moser,** University of Alberta.
Show that the maximum number of terms of different form in a polynomial of degree n in k variables is the same as the maximum number of terms of different form in a polynomial of degree k in n variables.

148. Proposed by M. S. Klamkin, State University of New York at Buffalo. Buffalo.
If a convex polygon has three angles of $60°$, show that it must be an equilateral triangle.

SOLUTIONS

124. Proposed by M. S. Klamkin, State University of New York at Buffalo.

Prove the impossibility of constructing the center of a circle with a straightedge only, given a chord and its midpoint. (For the original version of this problem see the spring, **1961** issue, p. 183).

The proof is a slight variation of the one given to prove the impossibility of constructing the center of a given circle with straightedge only (see H. Rademacher and O. Toeplitz, The Enjoyment of Mathematics, Princeton University Press, Princeton, 1957, pp. 177—180). It is established there, that there exists a conical projection transforming the given circle into another circle such that the centers do not correspond to each other. Now rotate the given circle about an axis through its center and perpendicular to its plane such that the given chord becomes parallel to the line of intersection formed by the planes of the two circles. It now follows that the midpoint of the chord transforms into the midpoint of the transformed chord (since they are both parallel). The impossibility of the construction now follows by a "Reductio ad Absurdum" argument. We first assume that the center of the given circle with a given chord and its midpoint can be constructed by straightedge **alone.** The previous construction immediately leads to a contradiction. For, whatever the construction might be, it would consist in drawing a certain number of straight lines and finding their intersection with one another and with the given circle with its given chord and midpoint. Now if the whole figure, consisting of the given circle, chord and midpoint, together with all the points and lines of construction, is conically-projected by the above transformation, the transformed figure will satisfy all the requirements of the construction, but will produce a point other than the center of the transformed circle. Consequently, such a construction is impossible.

While almost all of the previous proof is given in Rademacher and Toeplitz (ibid) and also R. Courant and H. Robbins, What is Mathematics, **Oxford University** Press, New York, 1943, P. 152, it was repeated here for the sake of completeness.

132. Proposed by L. Carlitz, Duke University.

Let p be an odd prime. Find the number of solutions (x, y, z) of the congruence

(1) $xyz + a(x+y+z) \equiv 0 \pmod p$,

where

$a \not\equiv 0 \pmod p$.

Solution by the proposer.

The congruence can be written as

(2) $(xy + a)z \equiv -a(x+y) \pmod p$.

If $xy + a \not\equiv 0$, then z is uniquely determined by (2); thus there are p^2-p+1 solutions satisfying this condition. On the other hand, if $xy + a \equiv 0$, it is necessary that $x + y \equiv 0$, and z is arbitrary. Now the system

$$xy + a \equiv 0, \quad x + y \equiv 0, \quad \pmod p,$$

reduces to $x^2 \equiv a$, which has it $1+\left(\frac{a}{p}\right)$ solutions, where $\left(\frac{a}{p}\right)$ is the **Legendre** symbol. Hence, the **total** number of **solutions is**

$$p^2 - p + 1 + p\left\{1+\left(\frac{a}{p}\right)\right\}.$$

134. Proposed by R. F. Wheeling and R. H. G. Mitchell, **Socony** Mobil Oil Company.

If $\phi_1(x)$ and $\phi_2(x)$ are one-dimensional probability density **functions (i.e.,** $\int_{-\infty}^{\infty}\phi_i(x)dx = 1$) and if there exists a number X_0 such that

$$\phi_2(x) \geq \phi_1(x) \quad \text{for } x > X_0,$$
$$\phi_2(x) \leq \phi_1(x) \quad \text{for } x < X_0,$$

then

$$\int_{-\infty}^{\infty} x\,\phi_2(x)\,dx \geq \int_{-\infty}^{\infty} x\,\phi_1(x)\,dx,$$

provided both integrals exist.

Solution by F. Zetto, Chicago, Illinois.

Since $[x-X_0]\,[\phi_2(x) - \phi_1(x)] \geq 0$, for $\infty > x > -\infty$ it follows that

$$\int_{-\infty}^{\infty} [x-X_0]\,[\phi_2(x) - \phi_1(x)]\,dx \geq 0,$$

or that

$$\int_{-\infty}^{\infty} x[\phi_2(x) - \phi_1(x)]\,dx \geq 0.$$

Also solved by Paul Meyers, **K.** Smith, J. Thomas, M. Wagner and the proposers.

135. Proposed by T. E. Hull, University of British Columbia.

Suppose that k points are placed uniformly around the **circumference** of a circle with unit radius. Show that the product of the distances from any one point to the others is equal to k, for any $k > 1$.

Solution by David L. **Silverman,** Beverly Hills, California.

Place the circle in the complex plane with center at (0, 0) and one vertex at (1, 0). The other vertices will then coincide with the kth roots of unity. If we denote them by $r_1 = 1, r_2, r_3, \ldots, r_k$ it follows that

$$z^k - 1 = \prod_{i=1}^{k} (z - r_i).$$

Consequently,

$$\prod_{i=2}^{k} (z - r_i) = 1 + z + z^2 + \cdots + z^{k-1}$$

The desired result is obtained by letting $z = 1$. Also solved by John T. Bagwell, Jr., H. Kave, Paul Meyers, Ted Newton, K. Smith, G. Tarns, M. Wagner, F. Zetto and the proposer.

Editorial Note: The same problem was proposed by Robert P. Goldberg in the November, 1961, Mathematics Magazine and solved in the May-June, 1962 issue.

ERRATA

106. Proposed by M. S. Klamkin, State University of New York at Buffalo.

An equi-angular point of an oval is defined to be a point such that all chords through the point form equal angles with the oval at both points of intersection (on the same side of the chord). It is a known elementary theorem that if all the interior points of an oval are equi-angular, then the oval is a circle.

1. Show that if one boundary point of an oval is equi-angular, the oval is a circle.
2. Determine a class of non-circular ovals containing at least one equi-angular point
3. It is conjectured that a non-circular oval can have, at most, one equi-angular point.

It has been pointed out by Michael Goldberg, Washington, D. C., that there is an error in the proposer's solution to part 2 (Fall, 1961 issue). He also gives a geometrical solution for this part. The corrected version of part 2 should read:

2. Let the origin be the equi-angular point Then we have to find r such that

$$r\frac{d\theta}{dr}\Big]_{\theta} + r\frac{d\theta}{dr}\Big]_{\theta+\pi} = 0, \quad \text{for all } \theta$$

One obvious solution is

$$\ln r = \int_0^{\infty} F(\sin \theta)\, d\theta$$

where F is odd, i.e.,

$$r = ae^{b\cos\theta}$$

BOOK REVIEWS

Edited by

FRANZ E. HOHN, UNIVERSITY OF ILLINOIS

Undergraduate Research in Mathematics, Report of a conference held at Carleton College, Northfield, Minnesota, June 19 to 23, 1961, with support from the National Science Foundation, edited by Kenneth O. May and Seymour Schuster. Carleton Duplicating Service, Northfield, Minnesota, 1961.

Despite the fact that "undergraduate research in mathematics" is not well defined, this report should be of great interest to anyone concerned with the development of mathematical maturity in undergraduate students. Although some of the conferees wished to restrict the term "research" to research leading to original results in mathematics worthy of publication in at least the Monthly, and others wished to extend the word to cover routine term papers of the nature found in undergraduate courses in, say, English, this reviewer feels that despite the semantic disagreement two important contributions are made in this report.

First, there is a discussion of the various techniques used to stimulate undergraduate study. These techniques include, among others, the Moore Method, undergraduate theses, undergraduate seminars, term papers, honors programs and honors sections, competitions, clubs, and local undergraduate publications. There are several detailed reports describing the utilization of these methods.

Second, there is a discussion of the support available for undergraduate research and independent study in mathematics under the NSF's Undergraduate Science Education Program. Here, the discussion ranged from the availability of NSF funds to a summary of the programs now being held under the NSF grants. Mathematicians, it appeared, have not been participating as actively in this program as other scientists.

For the very few hours needed to read this report, the time will be well spent.

University of Illinois — Hiram Paley

Inttoduction to Probability and Statistics, Second Edition. By H. L. Alder and E. B. Roessler. San Francisco, W. H. Freeman, 1962. xii + 289 pp., $5.50.

This second edition remains virtually unchanged from the first except for the addition of two new chapters on the F-distribution and analysis of variance. As before, the book is intended for use in a one-semester introductory course in statistics where calculus is not a prerequisite.

With the exception of brief discussions on index numbers and time series, the topics covered are the usual ones and,, as in other books written on this level, the quality of mathematics suffers. Of course, this is partly due to the severe limitations of writing about statistics on this level. However, at least some of the definitions could be improved. For example, the first definition given is: "A measurable characteristic is called a variable." Later on, we find: "A measurable characteristic of a population, such as its mean or standard deviation, is called a population parameter or simply a parameter."

A distinguishing positive feature of the book is the authors' easy, fluid style of writing. Also, there are hundreds of exercises requiring only a small amount of computation, and the answers are given in the back of the book.

University of Illinois — Gus Haggstrom

A Second Course in Number Theory. By Harvey Cohn. New York, Wiley, 1962. xiii + 276 pp., $8.00.

As the title of this book suggests, a reader needs as background a first course in number theory. But titles cannot reveal everything, and so it should be pointed out that a reader also needs some understanding of abstract algebra, particularly a little group theory. The author does give a review of elementary number theory and group theory, but this might not be easy reading without some prior familiarity with these topics.

Following this review material. Professor Cohn launches forth on his main topic, ideal theory in quadratic fields, including discussions of units, the algebra of ideals, unique factorization with ideals, norms, and class numbers. The third and final part of the book comprises the application of this theory of ideals to three topics: a proof of the Dirichlet theorem on the infinitude of primes in an arithmetic progression, quadratic reiprocity, and quadratic forms. There is a good bibliography and several numerical tables.

The writing has a historical orientation which is rare outside of books on the history and culture of mathematics. To illustrate this we cite two examples out of many. In the preface it is remarked that "A student completing this course should acquire an appreciation for the historical origins of linear algebra, for the zeta-function tradition, for ideal class structure, and for genus theory." On page 241 it is observed that "At this juncture number theory was strongly influenced by Riemann's theory of functions. . .

This book fills a gap in the literature very neatly. There is, in fact, no book (certainly not in English) covering these particular topics, although of course there are a few that overlap in minor ways. The author is to be congratulated on opening up a large area of mathematics to a wider class of readers. Graduate students will find that this book is one of those helpful works that serve as bridges between the more elementary books and the articles in the journals.

University of Oregon — Ivan Niven

Discrete Variable Methods in Ordinary Differential Equations. By Peter Henrici. New York, Wiley, 1962. xi + 407 pp., $11.50.

Professor Henrici has written a book which will be of vital interest to all students of numerical analysis. Although this book is concerned with the numerical solution of ordinary differential equations, the underlying concepts are of importance in all areas of numerical analysis. This text is the first book on the numerical solution of o.d.e. which was written with high speed digital computers in mind.

The book is divided into three parts which are as follows:

Part 1. One-step methods for initial value problems.

Part 2. Multistep methods for initial value problems.

Part 3. Boundary value problems.

In each part, there is a buildup of the theoretical apparatus with precise definitions followed by applications. There is a considerable discussion of roundoff error in terms of random variables, and the numerical examples show the appropriateness of the stochastic model. A good set of problems is given at the end of each chapter.

This book represents a standard of rigor and clarity which all future text books in numerical analysis should aim for.

Stanford University — Gene H. Golub

Theory of Numbers, Second Edition. By G. B. Mathews. New York, Chelsea, 1961. xii + 323 pp., $3.50 clothbound.

Conic Sections. By G. Salmon. New York, Chelsea, 1962. xv + 399 pp., $3.50 clothbound, $1.95 paperbound.

Projective Methods in Plane Analytical Geometry. By C. A. Scott. New York, Chelsea, 1961. xii + 290 pp., $3.50 clothbound.

The Logic of Chance. By J. Venn. New York, Chelsea, 1962. xxix + 508 pp., $4.95 clothbound, $2.25 paperbound.

These four books are reprints of classical works, originally published in the last century, that were outstanding in their day. They are famous for clarity, completeness, and charm and belong in every reference library.

University Calculus with Analytic Geometry. By C. B. Morrey, Jr. Reading, Mass., Addison-Wesley, 1962. xiv + 754 pp., $12.50.

Like many others of the modern texts published recently by Addison Wesley, this is another excellent book.

It is designed for a sequence of courses, totalling 12 semester hours, for students who are well prepared in algebra and trigonometry but who do not have any background in analytic geometry. The approach and the language of the book are definitely modern. Besides the usual topics discussed in most calculus books, the author devotes a substantial amount of space to analytic geometry and to the theory of vectors in the plane and in space. Theory is emphasized from the beginning, even to the point of requiring the student to prove many of the theorems as exercises.

An early chapter gives an introduction to the fundamental concepts of limit, differentiation, and integration. The discussion is informal at the start, but rigorous proofs are given of all essential theorems. Union, intersection, and difference of two sets and also interior points as well as limit points are defined and made use of in Chapter 8 on the definite integral. The differential is discussed carefully and extensively.

The reviewer recommends this book as a text where a combination geometry-calculus book course is in order.

University of Maryland — Dagmar Henney

Stochastic Service Systems. By John Riordan. New York, Wiley, 1962. + 139 pp., $6.75.

This book, a member of the SIAM Series in Applied Mathematics, is a well written introduction to the probability theory of queueing and traffic systems, and of certain variants of these which arise especially in telephone problems. The mathematical level is comparable to that of Feller's book, and a student who has had an introduction to probability theory from such a book should find little difficulty in reading Riordan's book. Many interesting topics which are not treated in standard references on queueing theory are contained in the book; for example, nonstandard queueing disciplines such as "last-come, first-served", systems with defections or balking, busy periods, etc. There are also historical remarks and references which are quite up-to-date.

Cornell University — J. Kiefer

Numerical Analysis, with Emphasis on the Application of Numerical Techniques to Problems of Infinitesimal Calculus in Single Variable, Second Edition. By Zdenek Kopal. New York, Wiley, 1962. xvi t 594 pp., $12.00.

The author has written a highly personal book which strongly reflects his own philosophy and interests. The numerical techniques described are mainly finite difference methods for approximating continuous problems. The first chapter gives a short history of number systems and numérical analysis. Chapters II through VII develop the classical subjects of numerical analysis - polynomial interpolation, numerical differentiation, intergration of o.d.e., boundary value problems, and mechanical quadrature. Chapter VIII describes methods for solving integral and integro-differential equations and Chapter IX is devoted to operational methods in numerical analysis which include polynomial and rational approximations. The book is concluded by several appendices which contain several useful tables.

Each chapter begins with motivational material. There are extensive bibliographical notes and problems at the conclusion of each chapter. Throughout the text, illustrative numerical examples are given.

Although this is a very readable and interesting book, it will find its greatest use as a reference for the practicing numerical analyst.

Stanford University — Gene H. Golub

Infinite Series. By I. I. Hirschman, Jr. New York, Holt, Rinehart, and Winston, 1962. x + 173 pp., $4.00.

This book is another welcome addition to the Athena Series of Holt, Rinehart and Winston. As other members of the series, it has an attractive format.

As an indication of the coverage, a listing of the chapter headings and the corresponding lengths in pages is as follows:

Chapter 1. Tests for Convergence and Divergence (35 pages).
2. Taylor Series (20 pages).
3. Fourier Series (25 pages).
4. Uniform Convergence (21 pages).
5. Rearrangements, Double Series, Summability (28 pages).
6. Power Series and Real Analytic Functions (18 pages).
7. Additional Topics in Fourier Series (14 pages).
Appendix
Set and Sequence Operations, Continuous Functions (6 pages)

Although the treatment is rigorous, emphasis has been placed upon the applications of the theory developed rather than upon the theory itself. Consequently, there is more material than usual on problems and applications, which, according to this reviewer, definitely enhances the book. The pace set by the author is rather leisurely, which should make the book attractive to those students studying on their own.

It should be noted that in problem 9, p. 15, it has been tacitly assumed that λ is a constant.

Otherwise, $\sum_{n=1}^{\infty} n^{-\lambda}$ can diverge even if $\lambda > 1$ (i.e. $\lambda = 1 + 1/n$).

Similarly for problem 11.

AVCO Corp. — M. S. Klamkin

Selected Topics in the Classical Theory of Functions of a Complex Variable. By M. H. Heins. New York, Holt, Rinehart and Winston, 1962. xi + 160 pp., $3.50.

The advent of the present monograph comes as a rare pleasure to the reviewer, as it must to other mathematicians who enjoy classical analysis and its recent developments. For many reasons this is a most interesting and stimulating book.

To begin with, the selection of topics has been done with considerable care. Among the contents are to be found the Cauchy-Goursat theorem, the Mittag-Leffler and Weierstrass theorems, the Riemann mapping theorem, the Bloch and Schottky theorems, the big Picard theorem, the theory of harmonic and subharmonic functions, the Dirichlet problem, the classification of regions (as hyperbolic and parabolic), the theorems of Iverson and Milloux-Schmidt, the Phragmén-Lindölof theorem, Wiman's theorem, Carleman's method, results on the boundary behavior of conformal mappings, and the strong form of the Cauchy integral theorem and formula. In a number of these areas the author has made significant research contributions, and this is not without influence on the development of the text.

A few of the topics discussed may already have been encountered by the student in a first course in function theory. If so, he will find it fruitful to renew his acquaintance with them here; the treatment is almost certain to be different in some respect from that previously seen. This difference is not merely for its own sake, however, since there is always a point to the author's departure from the traditional. For example, his use of Fourier series methods in deriving basic properties of analytic functions is highly illuminating, as is his presentation of the Caratheodory-Koebe proof of the Riemann mapping theorem.

The many topics that are new to the student will greatly enrich his knowledge of function theory and provide a base for attacking the current literature. Indeed, the latter facet of the book is perhaps its strongest. With due acknowledgement of Pólya and Szegö's celebrated *Aufgaben und Lehrsätze,* the author adopts a style in which the problems often form an integral part of the development. The student should therefore work all of them, as well as the informal problems which arise as details in the text itself. This poses a serious challenge, but the student who accepts it and works his way through the book's 155 pages will be amply rewarded in ability to cope with the research literature.

Alternatively, the book lends itself well to use as a source of advanced topics for inclusion toward the end of a first course in complex function theory. An attempt has been made to keep it reasonably self contained, even to the extent of inserting material from real function theory in the appendices, and many of the topics are treated independently of one another.

To carry out a program of the above sort is no mean task. The author has done it skillfully, particularly with regard to the organization of material and the difficult choice of what should be made explicit and what left to the reader. Not the least of the author's skills, however, is his command of a prose style which virtually puts the work in a class by itself. Pleasantly informal, the writing is filled with interesting observations, side remarks, and references, so that one almost has the feeling of being present at a well polished lecture. In all likelihood this book is destined to become a classic in its field.

University of Washington — Maynard G. Arsove

Geometrical Constructions Using Compasses Only. By A. N. Kostovskii. New York, Blaisdell, 1961. xi + 79 pp., $0.95. (Translated from the Russian by Halina Moss).

The Ruler in Geometrical Constructions. By A. S. Smogorzhevskii. New York, Blaisdell, 1961, viii + 86 pp., $0.95. (Translated from the Russian by Halina Moss).

These two booklets, presupposing hardly any more geometry than that to which an American high school student is generally exposed, form a readable introduction to the problems implied by the titles. The authors restrict themselves to the synthetic approach almost exclusively. They develop with a minimum of axiomatic formalization the additional ideas of inversive and projective geometry needed and which are not generally part of the beginning students' background.

These books should make excellent sources of additional material for high school students and will be of interest to anyone who has ever toyed with ruler and compass.

A highlight of the "Ruler" book is a proof of the impossibility of constructing with the ruler alone the centers of two given nonconcentric circles unless they intersect. However, beyond mentioning them, the three classical impossible construction problems are not discussed.

The translation is well done. Only two misprints were detected; these are too minor to point out.

University of Nebraska — Edwin Halfar

Handbook of Automation and Control, Volume 3. Edited by M. Grabbe, S. Ramo, and D. E. Wooldridge. New York, Wiley, 1961, xxi + 1153 pp., $19.75.

Preceding volumes of this Handbook were devoted to the fundamental theories of Logical Design and Information Theory (Vol. 1) and to Programming and Design of Computers (Vol. 2). The latest (and final) volume is called "Systems and Components"; a better title might have been "Process Control". The reviewer feels, as for the first two volumes, that overlap is considerable–compare Ch. 27 of Vol. 3 to Ch. 16 of Vol. 2— and that the depth of thought is highly variable--as witnessed by the complete irrelevance of Ch. 2 ("The Human Component") and the very fine treatment of "Transmission Systems" in Ch. 15.

It seems, however, that in overall quality this new volume is superior to the predecessors: The sections on "Manufacturing Process Control," "Chemical Process Control" and "Industrial Control Systems" (including Nuclear Reactors) are, in general, quite usable as a first introduction to the fields: This contrasts strongly with the approach of Vol. 2 which presupposes often a good deal of preliminary knowledge. Incidentally, Chapter 26 on "Semiconductor Devices" and Chapter 27 on "Transistor Circuits" (both of these are in the Component Section) are examples of outstanding clarity and show handbook writing at its best.

In summary: The reviewer wished that about 50% of the chapters were rewritten to reach the high level of competence of the other half. This criticism, however, can be levelled at almostany compendium. One should congratulate the editors for having achieved an entirely useful encyclopedia of the automation and control field. The density of information on the more than 3,000 pages is definitely high and, this is a very positive point, there seem to be practically no errors.

University of Illinois — W. J. Poppelbaum

Handbook of Statistical Tables. By D. B. Owen. Reading, Mass.. Addison-Wesley, 1962. xii + 580 pp., $12.50

This is an unusually complete collection of 113 tables of functions used in statistics, many of them more extensively tabulated than ever before. The volume will be much appreciated by both the advanced student and the practicing statistician.

An Introduction to Probability and Statistics. By Howard G. Tucker. New York, Academic Press, 1962. xii + 228 pp., $5.75.

Here is a bold new textbook on probability and statistics for undergraduate mathematics majors that differs radically in scope, depth, and presentation from others now on the market. For an introductory text, the author has given us a sound mathematics book which is concise, well written, and relatively free of errors.

In the preface the author draws attention to these features of the book:

"1. Random variables are treated as measurable functions.
2. Sampling is treated in terms of product spaces.
3. Distributions are derived by the transformation method.
4. Probability is given an axiomatic treatment.
5. A chapter on the matrix theory needed is inserted in the middle of the book.
6. The Neyman theory of confidence intervals is given a systematic treatment.
7. A more natural definition of the multivariate normal distribution is given.
8. Expectation is given a unified treatment; the expectation of a random variable X is defined to be

$$\int_0^\infty P[X>x]\,dx - \int_{-\infty}^0 P[X\leq x]\,dx,$$

provided that both of these improper Riemann integrals are finite. Formulas and properties in the discrete and absolutely continuous case are then derived from this definition."

A further indication of the content of the book is that among the theorems proved are a version of the Law of Large Numbers, the Neyman-Pearson Fundamental Lemma, the Cramer-Rao Inequality, and Cochran's Theorem.

Compared to other books aimed at the same level, relatively little space is devoted to motivational material and examples. The exercises are commonly used for filling in steps in proofs and for proving corollaries, but there are still many good exercises on applications. The answers are not given.

It is unfortunate that this excellent text may be at too high a level to be very useful in the classroom. Many teachers will find that a course based on this text will overshoot the maturity of their students, particularly if many of them come directly from calculus. More motivational material and examples would have been helpful without compromising the author's aim to write a sound introductory statistics book.

University of Illinois — Gus Haggstrom

Stability by Liapunov's Direct Method, with Applications. By Joseph **LaSalle** and Solomon **Lefschetz.** New York, Academic Press, **1961.** vii **+ 134** pp., **$5.50.**

This monograph, the fourth in a series edited by Richard **Bellman,** represents (according to the cover) the first "detailed and elementary account in English of **Liapunov's** direct (second) method." The book presents no new material but does give a concise account of Liapunov stability theory as it appears in the literature of the past two years. Indeed, in the short space of **134** pages the reader is at least introduced to some of the modern concepts of stability analysis in a rather painless and pleasing way.

In Chapter One, essential material is given for application in later chapters. Ideas are rapidly and lucidly presented in a manner which gives the student an opporunity to learn yet does not insult the more mature reader. By inclusion of this chapter, the book is rendered essentially self contained.

Chapter Two deals with differential equations, immediately and conclusively put in the normal form. The reader is guided quickly through the ideas of trajectories in phase space, critical points and eigenvalues, etc. A great deal of notation is brought out in this chapter and it appears that one entirely unfamiliar with the terminology might easily lose his way among the definitions. However, the main purpose of the chapter is to lay a solid mathematical foundation for the stability theory which is the subject of the book. Having previously given definitions and elementary properties of vector spaces and coordinate transformations, the authors now begin a careful, clear development of stability notions applied to the vector set of differential equations in normal form. Beginning with autonomous systems, Liapunov functions are defined and Liapunov's stability theorems are given with proofs either stated or outlined. Several types of stability are described and examples are given to explain the more subtle aspects of the theory. More general and practically important topics complete this chapter: Stability and the Theorems of Liapunov for Nonautonomous Systems, Converse of the Theorems of **Liapunov,** the Extent of Asymptotic Stability, Stability under Persistent Disturbances. Chapter Two contains the bulk of the theoretical development of Liapunov's work, condensed into fifty pages. This is, indeed, the main contribution of the book.

Chapter Three is devoted to the study of stability theory applied to control mechanisms. Several typical control problems are worked out in detail and and comments are made concerning more desirable ways to approach control problems. It might be considered that this chapter introduces a philosophy of control from the viewpoint of the mathematician. Such a discussion is important to the student learning to apply notions of stability to practical control problems and is welcomed by the systems **analyist** as an analytic approach to the quantitive study of non-linear control systems. The technical content of Chapter Three is not new to the scholar working the control field; however, it is a good concise source of pertinent information for reference.

Chapter Four is a collection of assorted topics in stability and is of interest primarily to the specialist.

In total, the book leaves a good impression. It might be criticized in that there is little discussion of the philosophy underlying the selection of **Liapunov** functions. Many of the coordinate transformations seem to have insufficient motivation at theoutset. The logic behind their selection is apparent only at later stages of the solution. Still, it must be admitted that most people attack stability problems this way and little is really known about the selection of Liapunov functions. This reviewer must emphasize, however, that several significant contributions have been made along these lines since publication of the book. Thus the text does not contain the current advances concerning selection of Liapunov functions. The unconventional notation used in numbering certain equations was confusing at first to **this** reviewer. In Chapter Three some simple block diagrams of the systems under discussion would have added to the clarity of the presentation. These minor criticisms are, however, offset by the clear style of discourse and appropriate geometrical diagrams which help give an insight into some of the subtle differences between the several types of stability described.

The book is well suited for use as a reference text in a course on stability or for self study. The authors have written a monograph which should be well received as a clear, concise introduction to an intensely important subject.

University of Illinois. Stephen **J. Kahne**

Lie Algebras. By Nathan Jacobson. New York, Wiley-Interscience, **1962. ix + 331** pp., **$10.50.**

This book gives a very concise, closely knit presentation of the theory of Lie algebras. The objective is to provide a thorough background in the most general context in recognition of the growing relevance of the theory in a number of different fields, such as Lie groups, algebraic groups, and free groups. In particular, the restrictions on the base field are minimal and are introduced only when necessary. For example, the classical classification of semi-simple Lie algebras is extended to split semi-simple Lie algebras, namely, those which have a **Cartan** subalgebra H such that for every **h C H,** adh has its characteristic roots in the base field. This is a fairly minor point, but it illustrates the spirit in which the author approaches the subject.

The prerequisites, as stated by the author, are a thorough foundation in linear algebra for the first nine chapters, plus some knowledge of Galois theory and the structure theory of associative algebras for the last chapter. This already puts the book out of reach of the average first year graduate student, to say nothing of that intangible, mathematical maturity, clearly necessary for negotiating such a compact work.

Briefly, the first four chapters are concerned with the structure of Lie algebras and the classification of the semi-simple ones. **Levi's** decomposition theorem and an introduction to the **cohomology** theory of Lie algebras are included, and **Dynkin's** method is followed in the classification. The next chapters are concerned with representations of Lie algebras. The universal enveloping algebra is introduced and used to reduce the problem to that of representations of associative algebras, the theorm of Ado-Iwasawa is proved, **Cartan's** classification of irreducible representations of a semi-simple Lie algebra is given, via modules, and **Weyl's** formula for the character of such a representation is derived. The ninth chapter studies the **automorphism** group of a Lie algebra, while in the last chapter the classification of simple Lie algebras over arbitrary fields of characteristic O is investigated. At the end of each chapter there is a section of stimulating, **non-trivial** problems.

Much of this material is obtainable elsewhere, ultimately in the **works** of E. **Cartan,** more readably in the volumes of Chevalley on Lie Groups, the Paris **"Sophus** Lie" seminar notes, **Bourbaki,** and the notes of H. **Freudenthal** on Lie groups. However, the completeness and generality of the present exposition make it a valuable addition to .the literature both as a reference and as a text for an advanced graduate course. Its appearance is sure to be welcomed by many experts in related fields.

Northwestern University R. J. **Crittenden**

The USSR Olympiad Problem Book. By **D. O. Shklarsky,** N. M Chentzov, and I. M **Yaglom.** San Francisco, W. H. Freeman, **1962. xvi + 452** pp., **$9.00.** (Revised, edited, and translated by I. **Sussman** and J. Maykovick.)

The Contest Problem Book. By Charles T. **Salkind.** New York, Random House, **1961.** vi **+ 154** pp., **$1.95.**

The first of these two books is a collection of unconventional problems of varying levels of difficulty, many new, some familiar, and a few very well-known The problems come from arithmetic, elementary number theory, analytical trigonometry, and algebra. Very **little** knowledge beyond that taught in college algebra and trigonometry is required for their solution. (When unusual knowledge is required, it is provided in the text.) **On** the other hand, many of them require a high degree of computational skill and insight.

The problems are **320** in number and are arranged according to subject matter. Their statement occupies the first **79** pages of the book. Then follow **343** pages of solutions and, for those who may give up less easily, **30** pages of hints and answers.

These problems are taken from the Olympiad contest examinations given to Russian students from the seventh to tenth grades, which correspond in academic attainment to our ninth to twelfth grades. However, the problems are interesting enough and difficult enough to be useful and challenging to college students in this country.

This volume is an attractive and valuable contribution to the mathematical literature.

The second of these collections is a compilation of the problems from the annual high school contests sponsored by the Mathematical Association of America. Solutions to the problems are given, as is an index which classifies the problems according to subject. The examinations are those for the years **1950** to **1960** inclusive.

These problems are easier than their Russian counterparts. They are also much more varied in nature and scope. (Geometry, for example, is well represented here.) As a result, this book will be more useful in high schools in this country than the first volume will. Indeed, it should be made available **to** every able mathematics student as a source of diversion, inspiration, and training in original **thinking.**

University of Illinois — Franz E. **Hohn**

Concepts of Tensor Analysis and Differential Geometry. By Tracy Y. Thomas. New York, Academic Press, **1961.** vii **+ 119** pp., **$5.00.**

This is the first volume in a series entitled **"Mathematics** in Science and Engineering" which is designed to present the theory and application of recent scientific and mathematical developments. The author of this volume gives an introductory account of the subject described in his title. He succeeds in including a great deal of the standard material in his twenty-five chapters. The brevity of his treatment will appeal to those students of applied mathematics who would like to become familiar with the formal aspects of the tensor calculus, and to many others who want only a bird's-eye view of the subject.

University of Illinois — Harry Levy

Lectures in Projective Geometry. By A. Seidenberg. Princeton, Van Nostrand, **1962.** x **+ 230** pp., **$6.50.**

This is an extremely well-written introduction to the subject, intended as a text for a two-semester course at the .junior or senior level in college. The author introduces the main topics of projective geometry on an intuitive basis "as an extension of high-school geometry", then proceeds axiomatically. The book is completely self-contained, even to the extent of introducing such topics as determinants — the stated prerequisites are two years of high-school mathematics. This greatly increases the accessibility of the material treated: the book could be recommended to the graduate student who has had no time and/or opportunity to take a course in geometry, or equally well to the **high-**school teacher wishing to enrich his background by independent study. Its value would seem greatest as a course text for the advanced undergraduate; even if one foresees no extensive study of geometry in his future, this is an excellent place to acquire familiarity both with the axiomatic method and with many of the basic concepts of abstract algebra — but a person using the text for the latter purpose should be cautioned that Professor Seidenberg's treatment might well entice him into a full-time study of geometry.

University of Chicago — D. A. Moran

Russian Reader in Pure and Applied Mathematics. By P. **H.** Nidditch. New York, **Wiley, 1962.** x **+ 166** pp., **$2.25.**

This little book contains one hundred brief readings from many different areas of pure and applied mathematics. The variety is excellent. Interlinear translations of all passages are provided. Extensive notes explaining all grammatical peculiarities are given. The book will be useful to all who are learning to read mathematical Russian. Indeed, it fills a long-felt need for a collection of specifically mathematical readings. Previous collections of scientific passages have only rarely included mathematical material.

University of Illinois — **Franz** E. **Hohn**

The Method of Mathematical Induction. By I. S. **Sominskii.** New York, Blaisdell, **1961.** vii **+ 57** pp., **$0.95.**

This little booklet begins by outlining the method of mathematical induction and pointing out the equivalence of this principle and the fact that any set of positive integers contains a smallest number. Examples are given in which induction fails because one of two essential components of a proof by induction is omitted or bungled.

There follow **52** theorems appropriate for proof by induction. Some are proved. These are chosen to illustrate a variety *of* techniques. Others are left as exercises. A brief chapter then gives proofs of some elementary theorems from algebra, and the final chapter gives solutions to the exercises some of which are particularly simple and some of which are challenging. Most *of* the examples and exercises deal with algebraic identities. Some familiar inequalities are also included. Very few geometrical theorems appear. No determinantal identities are given.

The book is easy to read. Since so little background **is** presumed, it is suitable for good high school students. They should find in it much that is of value but they may wish the style were a little livelier.

University of Illinois — Franz E. Hohn

Mathematical Statistics. By S. S. Wilks, New York, Wiley, 1962. xvi + 644 pp., **$15.00.**

Here is a book that may be fairly said to representthe solid core of modem statistical theory, carefully and systematically presented. The student who has **mastered** this volume will have a very thorough and balanced grasp of **the** present state of the subject, and will be in a good **position** to begin to work at the growing **edge of** this large area of mathematics.

The task of preparing an up-to-date account of any active field of mathematics is like trying to board a moving train. This book had its beginning in a **lithoprinted** text under the same title published by Princeton University Press in 1943. la the ensuing 19 years the subject has advanced so rapidly that one may say that the character of the book has radically changed since the **litho-**printed version. A few topics have receded into the background, or even disappeared. For example, in the original version therewas a section devoted to the **Pearson** system of distribution functions, and another to the chi-square test of goodness of fit; in the present text the first of these topics is not mentioned, and the second appears only in two exercises. Chapter IX of the early version was devoted to analysis of variance, treated from the regression standpoint; in the present version the term "analysis of variance" does not appear in the table of contents, although it is adequately treated in the text.

These changes are, of course, symptomatic of the extensive changes in matematical statistics over the pastseveral decades. Even more interesting from this standpoint are the topics appearing in Professor Wilks' new book that did not appear in the earlier one. Chapter 1, entitled "Preliminaries", contains a rather detailed account of the necessary set theory (including sequences of sets), **Borel** fields, probability measures, and probability spaces. These matters, if mentioned at all, received only passing mention in the earlier book. Chapter 16, on statistical decision functions, deals with a topic which, in 1943, was little more than a gleam in the eye of John von Neumann. The chapter presents a rather brief but entirely adequate account of certain central ideas of decision theory. Sequential statistical analysis, dealt with in Chapter 13, has likewise made its debut since 1943; in fact, it may be regarded as a forerunner of decision theory. Another new topic is that of time series, to which Chapter 17 is devoted.

According to the preface, "the purpose of this book is to introduce mathematical statistics to readers with good undergraduate backgrounds in mathematics." Only a very few undergraduates, however, would be sufficiently grounded in mathematics and in statistics to undertake to read this book at the beginning of their graduate work. It presumes a sophistication in set theory and **related** matters which is likely to be gained only in a rather solid course in real variables. The readerwithout considerable background in matrix theory would be in difficulties at some points, but this is more easily remedied. Finally, it **must be** said that this book needs to be supplemented by a good deal of experiencewith actual data. In practical terms, for almost all students this means that one or two preliminary courses in statistics should precede the study of this book. In this connection, **a** rather minor criticism is that although the term "experimental design" is used a number of times, it is never defined, as far as the reviewer could determine.

In summary, this is a book which will retain its usefulness for many years, and which is likely to become one of the permanent classics in the field of mathematical statistics.

Earlham College — Howard W. Alexander

Mathematical Programming. By S. Vajda. Reading, Mass., Addison-Wesley, 1961. ix + 310 pp., $8.50.

Suppose that N horses **run** in a race and that a gambler will receive a dollars for each dollar bet if the i^{th} horse wins and will lose the amount of the bet otherwise. How should the gambler divide his stake among the horses so that **his** smallest possible stake after the race is as large as possible?

To see thenature of this problem we may assume **that** the gambler's stake is unity and that he allocates the amount x_i to the i^{th} horse. Then these variables must satisfy the relations

$$x_1 + x_2 + \dots + x_N = 1$$

$$x_i \geq 0, \quad i = 1,2,\dots,N.$$

Furthermore, if the i^{th} horse wins, the gambler's stake will become

$$a_i x_i - (1-x_i) = (a_i + 1)\, x_i - 1.$$

If we let

$$\operatorname*{Min}_i \left[(a_i + 1)\, x_i - 1 \right] = v,$$

then our task is to choose the variables x_i **so as to** maximize the value of v. We may restate the relations and problem **to** read:

Choose the **non-negative** variables x_i subject to the conditions

$$(a_i + 1)x_i - 1 \geq v, \; i = 1,2,\dots,N,$$

$$\sum_{i=1}^{N} x_i = 1,$$

so as to permit the largest possible choice of the value v.

We have just stated a linear **programming** problem, the solution of which may be found in the book under review. The essential ingredients are that we consider a physical situation demanding an optimization, try to formulate the **problem mathematically** as the maximization of a linear form whose variables are subject to linear inequality constraints, and then solve the resulting equations computationally. It has been found in recent years that many problems in operations research, game theory, and engineering are of this type. The computational problem is enormous, since we may have to deal with hundreds of inequalities involving thousands of constraints.

The first four chapters of this book are preparatory in nature. Chapter five through eight form a satisfactory introduction to this field and are readily accessible to upper division and graduate students. Interesting **sets** of problems and answers are available so that the book is suitable for independent study. The **remaining** chapters, devoted to quadratic **programming,** stochastic linear programming, and dynamic programming, are not written in the lucid expository style for which the author is well known and may safely be avoided. A useful bibliography is included.

This is a useful introduction to a field that is rapidly growing in importance.

RAND Corporation — R. **Kalaba**

Higher Algebra for the Undergraduate, Second Edition. By M. Weiss. Revised by R. Dubisch. New York, Wiley, **1962. ix + 177** pp., **$4.95.**

This book may well be the answer to that difficult problem of changing from "cookbook" problem solving algebra to the axiomatic modem algebra of the present day. Usually, the transition is a very painful one for students and teachers alike. The students simply don't see the **need for** axioms, and for proving things which seem obviously true. They find **modern** algebra dull, and very troublesome, and even if they don't give up, they frequently end up with far from a love for the subject. This text should alleviate many of these difficulties.

The original edition was well received, and the present one, retaining the same spirit, will be widely used. Important material on linear algebra has been added, additional exercises included, and the format generally improved.

After introducing the real and complex number **systems, the** authors discuss the elementary theory of groups, rings, integral domains, and fields, pleasantly **guiding** the student through these abstract concepts. Next follow the subjects of polynomials, matrices, systems of equations and determinants. The last chapter is devoted to the important topic of homomophisms. Notice how the best (and most difficult) is saved to the last.

The reviewer feels that a careful study of this text should provide most of the material and much of the maturity needed for a serious graduate course in modem abstract algebra.

San Jose State College — T. J. **Cullen**

BOOKS RECEIVED FOR REVIEW

R. L. Ackoff: *Scientific Method: Optimizing Applied Research Decisions.* New York, Wiley, **1962.** xii + **464** pp., **$10.25.**

*H. L. Alder and E. B. Roessler: *Introduction to Probability and Statistics, Second Edition.* San Francisco, W. H. Freeman, **1962. xii + 289** pp., **$5.50.**

E. Beckenboch and R. **Bellman:** *An Introduction to Inequalities.* New York, Random House, **1961. 133** pp., **$1.95.**

C. Berge: *The Theory of Graphs and Its Applications.* New York, Wiley, **1962.** x + **247** pp., **$6.50.**

G. **Birkhoff** and G-C. Rota: *Ordinary **Differential** Equations.* Boston, **Ginn, 1962. vii + 318** pp., **$8.50.**

L. M. **Blumenthal:** *A Modern View of Geometry.* San Francisco, W. H. Freeman, **1961. xii + 191** pp., **$2.25,** paperbound.

R. C. Buck, Editor: *Studies in Modem Analysis.* Englewood Cliffs, New Jersey, Prentice-Hall, **1962.** viii + **182** pp., **$4.00.**

*H. Cohn: *A Second Course in Number Theory.* New York, Wiley, **1962.** xiii + **276** pp., **$8.00.**

P. J. Davis: *The Lore of Large Numbers.* New York, Random House, **1961. x + 165** pp., **$1.95.**

L. E. Elsgolc: ***Calculus** of Variations.* Reading, Mass., Addison-Wesley, **1962. 178** pp., **$4.50.**

B. Epstein: ***Partial** Differential Equations, An Introduction.* New York, **McGraw-Hill, 1962.** x + **273** pp., **$9.50.**

D. T. Finkbeiner, II. *Introduction to Matrices and Linear Transformations.* San Francisco, W. H. Freeman, **1960. ix + 246 pp., $6.50.**

F. P. Fowler, Jr. and E. W. Sandberg: *Basic Mathematics for **Administration.*** New York, Wiley, **1962.** xvii + **339** pp., **$7.95.**

B. A. **Fuchs** and B. V. Shobat: *Functions of a Complex Variable and Some **of** Their Applications.* Reading, Mass., Addison-Wesley, **1962. x + 286** pp., **$7.00.**

G. Fuller: *Analytic Geometry, Second Edition.* Reading, Mass., Addison-Wesley, **1962.** ix + **230** pp., **$5.75.**

B. V. Gnedenko: *Probability.* New York. Chelsea, **1962. 459** pp., **$8.75.**

S. L Goldberg: *Curvature and Homology.* New York, Academic Press, **1962.** xvii + **315** pp., **$8.50.**

M. Hamermesh: *Group Theory and its Applications to Physical Problems.* Reading, Mass., Addison-Wesley, **1962. xv + 509** pp., **$15.00.**

***M. Heins:** *Selected Topics in the Classical Theory of Functions of a Complex Variable.* New York, Holt, Rinehart and Winston, **1962.** xi + **160** pp., **$3.50.**

*P. **Henrici:** *Discrete Variable Methods in Ordinary Differential Equations.* New York, Wiley, **1962. xi + 407** pp., **$11.50.**

*I. L Hirschman: *Infinite Series.* New York, Holt, Rinehart and **Winston, 1962.** x + **173** pp., **$4.00.**

*N. Jacobson: *Lie Algebras.* New York, Wiley-Interscience, **1962. ix + 331** pp., **$10.50.**

N. D. **Kazarinoff:** *Geometric **Inequalities.*** New York. Random House. **1961. 132** pp., **$1.95.**

E. S. Keeping: *Introduction to **Statistical** Inference.* **Princeton,** Van Nostrand. **1962. xi + 451** pp., **$8.50.**

J. G. Kemeny, A. **Schleifer,** Jr., J. Laurie Snell, and G. L. Thompson: *Finite Mathematics with Business Applications.* Englewood Cliffs, **N. J.,** Rentice-Hall, **1962. xii + 482 pp., $10.60.**

*Z. **Kopal:** *Numerical Analysis, Second Edition.* New York. Wiley, **1962. xvi + 594** pp., **$12.00.**

N. H. **Kuiper:** *Linear **Algebra** and Geometry.* New York, Wiley, **1962.** viii + 285 pp., **$8.25.**

K. Kuratowski: *Introduction to **Calculus.*** Reading, Mass., Addison-Wesley, **1962. 315** pp., **$5.00.**

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*C. B. Morrey, Jr.: *University **Calculus** with Analytic Geometry.* Reading, Mass., Addison-Wesley. **1962.** xiv + **754** pp., **$12.50.**

M. M. Nicolson: *Fundamentals and Techniques of Mathematics for Scientists.* New York, Wiley, **1962.** xx + **526** pp., **$7.50.**

*P. H. Nidditch: *Russian Reader in Pure and Applied Mathematics.* New York, Wiley, **1962.** x + **166** pp., **$2.25.**

L Niven: *Numbers: Rational and **Irrational.*** New York, Random House, **1961.** viii + **136** pp., **$1.95.**

D. B. Owen: *Handbook of **Statistical** Tables.* Reading, Mass., Addison-Wesley, **1962. xii + 580** pp., **$12.50.**

G. Polya: ***Mathematical Discovery, Vol. I.*** New York, Wiley, 1962. xv + 216 pp., $4.75.

*J. Riordan: ***Stochastic Service Systems.*** New York, Wiley, 1962. x + 139 pp., $6.75.

J. B. Roberts: ***The Real Number System in an Algebraic Setting.*** San Francisco, Freeman, 1962. 145 pp., $3.50 hardcover, $1.75 paperbound.

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*G. Salmon: ***Conic Sections (Reprint).*** New York, Chelsea, 1962. xv + 399 pp., $3.50 clothbound, $1.95 paperbound.

W. W. Sawyer: ***What is Calculus About?*** New York, Random House, 1961. vi + 118 pp., $1.95.

F. J. Scheid: ***Elements of Finite Mathematics.*** Reading, Mass., Addison-Wesley, 1962. vii + 279 pp., $6.75.

S. Schuster: ***Elementary Vector Geometry.*** New York, Wiley, 1962. xii + 213 pp., $4.95.

*A. Seidenberg: ***Lectures in Projective Geometry.*** Princeton, Van Nostrand, 1962. x + 230 pp., $6.50.

*D. O. Shklarsky, N. N. Chentzov, and I. M. Yaglom: ***The U.S.S.R. Olympiad Problem Book.*** San Francisco, Freeman, 1962. xvi + 452 pp., $9.00.

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R. R. Stoll: ***Sets, Logic, and Axiomatic Theories.*** San Francisco, Freeman, 1961. x + 206 pp., $2.25, paperbound.

*T. Y. Thomas: ***Concepts from Tensor Analysis and Differential Geometry.*** New York, Academic Press, 1961. vii + 119 pp., $5.00.

T. Y. Thomas: ***Plastic Flow and Fracture in Solids.*** New York, Academic Press, 1961. ix + 267 pp., $8.50.

J. Todd: ***A Survey of Numerical Analysis.*** New York, McGraw-Hill, 1962. xvi + 589 pp., $12.50.

*H. G. Tucker: ***An Introduction*** to ***Probability and Mathematical Statistics.*** New York, Academic Press, 1962. ix + 228 pp., $5.75.

*J. Venn: ***Logic of Chance (Reprint).*** New York, Chelsea, 1962. xxix + 508 pp., $4.95 clothbound, $2.25 paperbound.

*M. Weiss and R. Dubisch: ***Higher Algebra for the Undergraduate, Second Edition.*** New York, Wiley, 1962. ix + 171 pp., $4.95.

H. S. Wilf: ***Mathematics for the Physical Sciences.*** New York, Wiley, 1962. xii + 284 pp., $7.95.

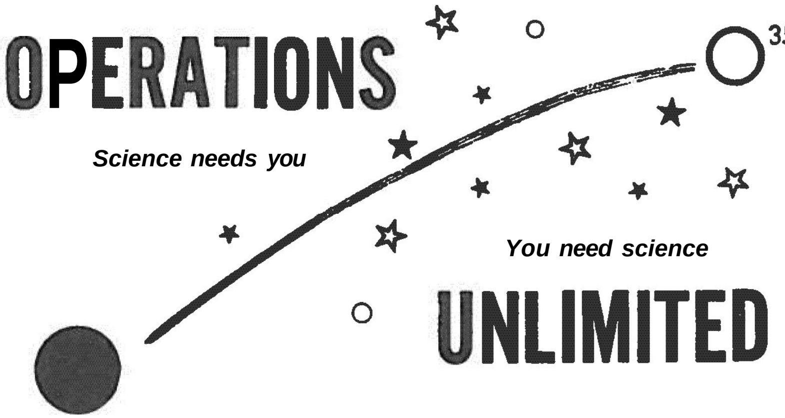
*S. S. Wilks: ***Mathematical Statistics.*** New York, Wiley, 1962. xvi + 644 pp., $15.00.

*See review, this issue.

NOTE: All correspondence concerning reviews and all books for review should be sent to PROFESSOR FRANZ E. HOHN, 374 ALTGELD HALL, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS.

NOTICE TO INITIATES

On initiation into Pi Mu Epsilon Fraternity, you are entitled to two copies of the Journal. It is your responsibility to keep the business office informed of your correct address, at which delivery will be assured. When you change address. please advise the business office of the Journal.



This section of the Journal is devoted to encouraging advanced study in mathematics and the sciences. Never has the need for advanced study been as essential as today.

Your election as members of Pi Mu Epsilon Fraternity is an indication of scientific potenital. Can you pursue advanced study in your field of specialization?

To point out the need of advanced study, the self-satisfaction of scientific achievement, the rewards for advanced preparation, the assistance available for qualified students, etc., we are publishing editorials, prepared by our country's leading scientific institutions, to show their interest in advanced study and in you.

Through these and future editorials it is planned to show the need of America's scientific industries for more highly trained personnel and their interest in scholars with advanced training.

The National Aeronautics and Space Administration was established in 1958 to conduct research into space problems of flight and vehicles, conduct activities for space exploration, and to provide the widest appropriate dissemination of information on these activities. We are fortunate to have an article by Dr. Mattison L. Story from the Educational Services Branch of NASA in this issue. Certainly mathematics in this respect helps make the satelites go round.

The Aeronautical Charting and Information Center is responsible for providing the Air Force with aeronautical charts, flight information, terrain models, maps, intelligence on air facilities, and related cartographic services as well as the research necessary to carry out these objectives. Mr. J. Donald Define, mathematician in the Geophysical Studies Section of the Geo-Sciences Branch of ACIC, has participated in this program to increase interest in mathematics, science, and research with a very interesting article, published in this issue.

The following lists contributing corporations with the issue in which their editorials appeared.

Aeronautical Chart and Information Center	Vol. 3, No. 7
Aeronutronics	Vol. 3, No. 2
Army Ballistic Missile Agency	Vol. 2, No. 10
AVCO, Research and Advanced Development	Vol. 2, No. 10
Bell Telephone Laboratories	Vol. 2, No. 10
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MATHEMATICS AND NATIONAL PURPOSE

MATTISON L. STORY
Education Specialist
National Aeronautics & Space Adm.
Washington, D. C.

Quantification processes are becoming increasingly vital to every aspect of our national life. Today's complex systems, which are nowhere more evident than in our prodigious space program, daily reflect the endless miracles of modem mathematics. Our so-called "leaping technology" is, in the fullest sense, uniquely dependent upon the amazingly rapid calculations and precise exactitudes now possible in this all-important realm.

The immense challenge which the "organized complexity" of modem life constantly poses could never be met without the systematic formulations and concise organizing principles which mathematics indispensably furnishes. Each Gargantuan accomplishment in modem space technology can be attributed to some specific new implementation of theorem or formula -- the actual physical structuring of complex instruments from symbolic predesigns.

It is thus entirely safe to say that mathematics has become a basic and essential tool of national purpose. The vast space enterprise undoubtedly furnishes the single, most dramatic evidence of its strategic new role as a kind of bellwether of national progress. Its increasing essentiality in all areas, stemming again from inevitable conditions of growth and complexity, can be equally demonstrated in the many diverse facets of our daily life as we cope with such commonplaces as gross national product, standard-of-living indices, opinion poll techniques, and population-explosion predictions.

The status of mathematics in relation to other educational disciplines has perhaps undergone a comparable change. While never actually subordinated, it has often been regarded as occupying the position of a prerequisite or intermediate discipline in the curricular scale. Today it is additionally claiming a highly independent stature as a kind of interface between man's scientific concepts and the vehicles and artifacts which enable him to bring them to realization.

Evidence of the dramatically changed status of mathematics can be demonstrated in a variety of ways. A highly pragmatic aspect of its enhanced recognition lies in the simple fact that mathematical know-how is now worth a great deal of money. Happily, the professional skills of the trained mathematician are not readily marketable but continue to be in the highest possible demand.

Far more significant, as a factor of change, is the growth of a new attitude toward the mathematician. He has, in a real sense, become the new heroic image of our society. Nothing is of greater social significance, perhaps, than our changing ethic of heroism which promises to supplant the warrior with the thinker as a symbol of greatness. The archetypal hero, traditionally celebrated in epic and fable, has invariably been the man of action, the warrior-statesman whose deeds of physical prowess marked him out for leadership and for worshipful adulation of the masses. The emergence of such intellectual giants as Albert Einstein to positions of widespread public recognition and heroic esteem augurs well for a future in which a new and civilizing recognition of intellectual greatness will perhaps become the keystone of our value system.

The gratifying progress now being made in the improvement of mathematics education is perhaps the most felicitous trend of all. Not only in our advanced curricula for specialized mathematics students but in the common core of education for all citizens, mathematics programs are being **strenthened** and refurbished in school systems throughout the land. This is our surest guarantee of national prestige. It is the bedrock of our future space program. Nothing is more heartening than this recognition that a widespread study of mathematics is, in effect, the best means of strengthening and undergirding our national potential for future greatness.

AERONAUTICAL CHART AND INFORMATION CENTER

ACIC AND ITS AEROSPACE MISSION

By
J. Donald Define
Geophysical Studies Section
Geo-Sciences Branch of ACIC

Mathematics, the Queen of the Sciences, is inherent in many fields, often where least expected. At the Aeronautical Chart and Information Center (ACIC), you might expect to find a large cartographic operation producing many navigational charts and aids for normal use as well as special support activities such as the Mercury Orbit Chart which has been and will be used by the Astronauts. Some glimmer of the Aerospace Mission might have come to your attention when reading of the Center's work on Lunar Charts and the production of a Lunar Atlas as part of the preparation for a manned lunar landing. At this point however, you might consider this the sum total of **ACIC's** work and, as a mathematician, consider that the cartographic field, even when allied with astronomy, is not a field worthy of your attention.

However, this impression, as with many impressions, only partially reveals the situation. Specifically, there are a number of fields with which the Centet is concerned: Cartography, certainly, but also photogrammetry, geodesy, and astronomy along with the requisite computer support.

Cartography, although basically concerned with accurate geographic portrayal, must preserve certain physical relationships of the earth's surface as precisely as possible. One of the more challenging aspects of cartography is the separate field of map projections where the principal concern is the representation of a three dimensional space. Here a good mathematical background is essential with emphasis on such areas of study as Theory of Functions of a Complex Variable, Differential Geometry of Curves and Surfaces and Advanced Calculus.

Photogrammetry is involved principally with obtaining reliable measurements through photography. At ACIC, aerial photographs are used to provide improved cartographic coverage. What sort of background is needed for a photogrammetrist? Error Theory, Matrix

Algebra, Vector Analysis and Least Squares Adjustments are certainly essential.

Geodesy - the science involving study of the exact size and shape of the earth and its internal structure - is a branch of applied mathematics. In the future, geodesy will surely embrace a similar study of the moon (selenodesy) and most probably'the planets - the term planetodesy has already been proposed. A variety of subjects are required background for this science. Geodesists are keenly interested in positioning points on a non-mathematical surface, the geoid, which is an equipotential mean sea level surface; and the transfer of the points to a mathematical surface, the ellipsoid, for distance and azimuth computations. Some essential mathematical tools include: Numerical Analysis (including the Numerical Solution of Differential Equations, Numerical Integration, Fourier Analysis, Legendre Polynomials and Least Squares), Vector Analysis, Matrix Algebra, Projective and Differential Geometry, Bessel Functions, Spherical Harmonics, Theory of the Potential, Error Theory and Probability and a smattering of Matrix and Tensor Calculus.

Astronomy may be considered as another branch of applied mathematics. Positional astronomy is used to determine point locations on the earth's surface and, together with geodesy, contributes to determination of the earth's size and shape. Solar eclipses, star occultations, precise observations of the moon and of the motion of artificial earth satellites are of vital interest to ACIC astronomers. Background mathematics should include: Bessel Functions, Legendre Polynomials, Least Squares Adjustments, Calculus of Finite Differences, Differential Correction Methods, Celestial Mechanics, Potential Theory, and Numerical Integration of Orbits.

The academic background of an applied mathematician at ACIC must be varied and, at the same time, complete. To provide some of the necessary knowledge, ACIC has offered individuals with appropriate mathematical foundation the opportunity of attending one year of advanced training in geodesy and photogrammetry at the Ohio State University's Institute of Cartography, Photogrammetry, and Geodesy. Similarly, a number of qualified ACIC employees have received graduate instruction in astronomy at the University of Cincinnati and the Yale University Observatory. Advanced mathematics and computer courses are included in both programs. The Center will no doubt continue to provide advanced training related to current and future projects.

Mathematicians are an integral part of the technical and scientific work force at ACIC. A variety of opportunity exists for the application of mathematical knowledge to the cartographic, photogrammetric, geodetic, and astronomic projects currently in work at the Center or anticipated for the future to support the USAF aerospace effort.

NEWS AND NOTICES

Edited By
Mary L. Cummings, University of Missouri

Army Major Robert J. Weeks, a 1949 graduate of the University of Illinois, was one of a class of 665 U. S. officers and 85 officers from 48 allied nations, who completed the regular course at the U. S. Command and General Staff College, Fort Leavenworth, Kansas, June, 1962.

Army Second Lieutenant Eldon J. Nosari recently completed the eight week officer orientation course at the Artillery and Missile Center, Fort Sill, Oklahoma. He received bachelor's and master's degrees from the University of Arkansas, and was formerly an instructor at the University.

Army Second Lieutenant Bruce C. Tyson, Jr. has been assigned to the Chemical Research and Development Laboratories at the U. S. Army Chemical Center, Maryland. He is a 1958 graduate of Duke University and a 1960 graduate of Princeton University.

Army Second Lieutenant Alfred E. Bruns, recently completed the eight week field artillery officer orientation course at the Artillery and Missile School, Fort Sill, Oklahoma. The school emphasizes leadership as well as the practical application of artillery tactics and techniques. Lt. Bruns is a graduate of the University of Missouri.

Paul Henley, a 1962 graduate of the College of Engineering, University of Missouri, has received a Chemical and Engineering News merit award as one of the country's outstanding scholars. He is one of twelve students from American universities to receive the 1962 award, which is given for scholarship and outstanding achievement in campus extra-curricular activities. In March, 1961, Henley was presented the American Institute of Chemical Engineers Scholarship Award as the member of the student chapter of the Institute at the University with the highest scholastic rating during his freshman and sophomore years.

We note with interest that Henley was the 1961 captain of the University of Missouri football team. As left guard, he made the All Conference first team during his junior year, while during his senior year he was named to the second team in both the Academic All American and All Conference selections.

A lecture by the famous French mathematician, Professor Jean Dieudonne, was the high point of a series of lectures presented by Pi Mu Epsilon at the University of Maryland. Seventy-five midshipment of the Naval Academy were present at the lecture in addition to many others. Dr. Dieudonne" outlined the aims and methods of that famous body of French mathematicians (the Bourbaki group) that tries to put order into large chunks of mathematics. Though they try to classify mathematics, they do not attempt to write an encyclopedia. The books published by the society are painstakingly prepared, the completion of a single book taking perhaps ten to twenty years. One person is elected to write a first draft of the book, which is read during a general session and discussed at great length. A second man writes a second draft, and it is read during the following year, with further examination and rewriting. Finally, after ten, twelve, fourteen years, if agreement has been reached, the work is turned over to the editor.

Professor Dieudonne treated his audience to some astounding remarks, namely, that trigonometry and analytic geometry are silly subjects taught in a silly way, and that lattice theory and non-associative algebra are weeds in the rapidly growing theory of mathematics. What do *you* **think?**

At the University of Kentucky, the Pi Mu Epsilon Distinguished Mathematician Award for scholastic achievement went to Thomas Steadman Bagby. He received mathematics books valued at ten dollars and ten more dollars to be spent on books of his choice.

The Pi Mu Epsilon Key Award for the best graduate seminar paper-content and presentation was presented to Jim Caveny. The award consists of a Pi Mu Epsilon key and a book award equivalent to that of Mr. **Bagby.**

The Pi Mu Epsilon chapter at the University of Buffalo awarded Richard M. Meyer and Albert D. **Polimeni** memberships in the Mathematical Association of America, the former for having achieved the highest average in mathematics, and the latter for having obtained the highest grade on the comprehensive examinations.

We wish to point out that **Carleton** College, which **has one** of our newest chapters, publishes a journal of undergraduate mathematics called Delta *Epsilon.* It is published by students and faculty of the college and serves as "a medium for immediate publication for private circulation and discussion of undergraduate **work."** Donald C. **Olivier** is student editor, while Professor Kenneth O. May is faculty editor. The paper first appeared in **1960.** A four year grant from toe National Science Foundation enables the staff to continue with the publication.

Students and faculty at Carleton, **alumni** of the college, mathematicians at other institutions interested in undergraduate research, and libraries, may receive Delta Epsilon by requesting it.

Two members of Pi Mu Epsilon at the University of Missouri, Wilson E. **Brumley,** and David Norman Martin, were graduated with honors in **mathematics.** Both **Brumley** and Martin held Continental Oil Company scholarships.

Other members at the University of Missouri receiving awards and scholarships were:

David O. Lambeth, a Henry N. Ess Scholarship for scholastic excellence.

Patrick D. Harris, Bendix Aviation Corporation Honors Scholarship in Science and Engineering. Harris also received the Weinbach Prize in Electrical Engineering for being the highest ranking member of the graduating class in electrical engineering.

Kathryn Lee Boehm, the Sigma Delta Epsilon Award of **$25** for excellence in science.

Billy G. Kay, Hamilton Watch Award to the person who has most successfully combined a proficiency in his major field of science with achievements in the social sciences and the humanities. Kay also received the Missouri Engineers of Chicago Scholarship.

Herbert Black, the Frederick O. Norton Memorial Prize for high scholastic standing and promise of leadership in social service appropriate to the enginerring profession.

Edward K. Bower, first prize in the annual Calculus Competition.

Mathukumalli Vidyasagar, second prize in the Calculus Competition.

DIGITAL COMPUTING FOR PROMISING UNDERGRADUATES

Beginning June **17, 1963,** the Digital Computer Laboratory of the University of Illinois will conduct an eight-week undergraduate training and working program, concerned with the use and construction of computers, for a limited number of advanced undergraduates.

Students in residence at any college or university in the United States or Canada who will be juniors or seniors in the fall of **1963** and who are interested in learning about and working with stored-program digital computers are invited to apply for admission.

Successful applicants will receive a stipend of **$400.00** and travel expenses to and from Urbana, Illinois.

No academic credit will be given to students engaged in this program.

Application forms may be obtained by writing to Professor C. W. Gear, Digital Computer Laboratory, University of Illinois, Urbana, Illinois.

The closing date for receiving applications is February **15, 1963.**

A STATEMENT ON THE PEACE CORPS
FROM
R. SARGENT SHRIVER, JR., DIRECTOR

The United States is sending some of its most outstanding young men and women as Peace Corps Volunteers to the developing nations. As teachers, engineers, nurses, coaches and surveyors, and in community development work, these Volunteers are providing leadership and knowledge to people throughout the world.

Fraternities and sororities have prided themselves on their ability to attract and develop leadership. Responsibility, too, has come with this leadership.

Let me suggest that an even greater responsibility and challenge awaits you now. The chance to serve overseas, and thus to continue the work of more than **4,000** Peace Corps Volunteers now in toe field, offers a rare fulfillment and experience. Inform yourself about the Peace Corps and how you may become a part of it after college. Contact the Peace Corps Liaison Officer on your campus, or write directly to PEACE CORPS, College and University Division, Washington **25,** D.C.

NEW CHAPTERS INSTALLED

On April **19, 1962,** Professor J. Sutherland Frame installed Utah Beta Chapter (the eighty-seventh) of Pi Mu Epsilon at Utah State University in Logan, Utah.

The charter members were thirteen iniates, namely, **Antone Bringhurst,** Lavelle Day, Norman Eggert, Julia Frandsen, Danny Goodrich, Robert Hammond, Ivan Keller, Mary Nelson, Janet Olsen, Bruce **Orcutt,** Paul Peterson, Wendell Pope, Wayne Rich, and four former members of the fraternity: Lawrence Cannon, Neville **Hunsaker,** Konrad Suprunowicz, E. E. Underwood.

Before the installation, Professor Frame gave a lecture on "Continued Fractions"; at the banquet he gave a talk about the history of Pi Mu Epsilon and showed some of the historical documents.

The eighty-eighth chapter, Rhode Island Alpha, was installed on April **26,** at the University of Rhode Island in Kingston. Professor Frame was again the installing officer. The installation ceremony was at **4:30** p.m., followed by a banquet at **5:30** both events taking place at the Larchmont Inn at nearby Wakefield. Later, Professor Frame gave a talk on "A Bridge to Relativity." Charter members were Harry Bender, Mary Cummings, Albert Bennett, Carl Garabedian, Jerald Greenberg, John James, Clifford **Leitaco,** E. M. J. Pease, Nancy Randall, Jacob Stauffer, **Rammath** Suryanarayan. The following additional nine members were initiated after the presentation of the charter: Richard Bender, Joel Cohen, Diana Drew, James Foster, **Domenick Lombari,** Mersima Moskos, Maureen **Russo,** Robert Salhany, Ronald **Tourgee.**

CHAPTER ACTIVITIES

Edited By

Houston T. Karnes, Louisiana State University

EDITOR'S NOTE: According to Article VI, Section 3 of the Constitution: "The Secretary shall keep account of all meetings and transactions of the chapter and, before the close of the academic year, shall send to the Secretary General and to the Director General, an **annual** report of the chapter activities including programs, results of elections, etc." The Secretary General now suggests that an additional copy of the annual report of each chapter be sent to the editor of this department of the Pi *Mu Epsilon Journal.* Besides the information listed above, we are especially interested in learning what the chapters are doing by way of competitive examinations, medals, prizes and scholarships, news and notices concerning members, active and alumni. Please send reports to Chapter Activities Editor Houston T. **Karnes,** Department of Mathematics, Louisiana State University, Baton Rouge 3, Louisiana. These reports will be published in the chronological order in which they are received.

REPORTS OF THE CHAPTERS

ALPHA OF MARYLAND, University of Maryland

The Maryland Alpha Chapter held nine meetings during the academic year 1961-62. The following papers were presented:

"**Bourbaki,**" by Professor Jean **Dieudonne,** France.

"Adele Algebra," by Professor Andre Well.

"The Four Vertex Theorem," by Professor Stanley Jackson.

"Why Use **29?**" by Professor Richard A. Good.

"Solving Linear Algebraic Systems on a Computer," by L. **Kenton** Meals, Head of Engineering Application Branch at the David Taylor Model Basin

'Determining Pi to 100,000 Digits," by Dr. Daniel Shanks, DTMB.

"Foundations of Probability and Statistics," by Dr. Syski.

Professor Jean Dieudonne **gave** the initiation dinner address. The title of his paper was. "A Panorama of Mathematics." Sixteen new members were initiated. Professor Leon Cohen, Chairman of the Mathematics Department, awarded the Abramowitz prize in Mathematics to an undergraduate student: Mr. Hyman. A scroll was presented to the faculty **advisor, Mrs. Dagmar** Henny, as a token of appreciation for time and effort given to the Chapter.

Miss Evelyn **Wooley** was the winner of a puzzle-solving contest sponsored by the Chapter.

Officers for 1961-62 were: Director, Howard Wilson; Vice-Director, David Sprecher; Treasurer, Den-ill Bordelon; Secretary, Alan G. Henney; Faculty Advisor, Mrs. Dagmar R. Henney.

GAMMA OF MISSOURI, St. Louis University.

The Missouri Gamma Chapter held four meetings during the academic year 1961-62. The following papers were presented:

"Symmetric and Self-Distributive Systems," by Mr. Patrick Cassens.

"Group Multiplication by Computers," by Mr. Grattan P. Murphy.

"Plane **Polygons,**" by Mr. Gerald Harshany.

"What is Topology?" by Dr. Saunders **MacLane,** University of Chicago.

One hundred seventy-two new members were initiated into the Chapter this year.

At the annual banquet Dr. Waldo Vezeau presented the following awards: Pi Mu Epsilon Contest - Senior Division, Mr. **Al** Ciplickas; Junior Division, Mr. Nick **Eissen.** Freshman Achievement Award - Miss Mary Middleton. James W. Garneau Mathematics Award for the Outstanding Senior – Mr. Suthep Chanthrasomsak.

At the first meeting of the year Mr. William Reddy was elected **Vice-**Director to succeed Mr. Richard Doyle and Miss Barbara **Resnik** was elected Secretary to succeed Miss **Marceline** C. Gratiaa. At the final meeting, Mr. S. Patrick Cassens was elected Director for 1962-63. Dr. Francis **Regan** has resigned from the position of Faculty Advisor and permanent **Secretary-**Treasurer of the Chapter and Dr. Edwin Eigel, Jr. will succeed him.

BETA OF FLORIDA, Florida State University

The Florida Beta Chapter held eight meetings during the academic year 1961-62. The following papers were presented:

'Fibonacci Sequence," by Mr. **Donadl VanderJagt.**

"Contributions of Geometry to Mathematics," by Dr. Raymond Wilder, University **of Michigan.**

' A Conjecture of **Borsuk's -** A Problem in n-Dimensional Space," by Dr. R. W. Jollensten, National Security Agency.

"Geometric Construction with Compass Alone," by Mr. Peter Rice.

"Ancient Number Systems," by Mr. Fredrick Zerla.

"Inter-Product Spaces," by Dr. Ralph **McWilliams.**

During the year, twenty-eight new members were initiated into the Chapter.

Officers for 1962-63 are: Director, Peter Rice; Vice-Director, Chris **Schaufele;** Secretary-Treasurer, Sharon Moses; and Faculty Advisor, Dr. H. **C.** Griffith.

ALPHA OF GEORGIA, University of Georgia

The Georgia Alpha Chapter held twelve meetings during the academic year 1961-62. The following papers were presented:

"Why Statistics?" by Dr. C. H. **Kapadia.**

"**Osgood's** Curve," by Dr. John Jewett.

""Programming the 1620 IBM Computer," by Mr. J. C. **Fortson.**

'Join Systems," by Mr. Gene Worth.

"Dimension Raising Functions," by Mr. Mike **Donahue.**

"Computer Programming," by Mr. L. **M. Quattelbaum.**

"Functions Everywhere Continuous and Nowhere Differentiable," by Mr. Julio **Bastida.**

"Implicit Function Theorem," by Mr. Britt Williams.

"Semigroups," by Mr. Chun Jai Rhee.

"Why the Number Pi is **Transendental,**" by Dr. L. W. Anderson.

"Mathematics of Antiquity," by Dr. R. P. Hunter.

"Odds at Dice," by Dr. J. H. Henkel.

Officers for the spring quarter, 1962 through the winter quarter, 1963 are: Director. Charles Christmas; Vice-Director, Earl Lavendar; Secretary, Saralyn Souter; and Treasurer, John Boyd.

GAMMA OF NEW YORK, Brooklyn College

The New York Gamma Chapter held five meetings during the academic year 1961-62. The following papers were presented:

"Theory of Groups," (a **series** of three lectures) by Robert Kaufman, Nathaniel Riesenberg, and Michael Tinkler.

"Cardinal Numbers," by Nathaniel Riesenberg.

'Creativity in Mathematics," by Professor James Singer, Chairman, Department of Mathematics.

Honorable Mention in the National Science Fellowship competition was given to Larry Smith, Nathaniel Riesenberg, Charles Rose, and Harvey **Abramson.**

Seven of the Chapter's graduates will be entering graduate schools throughout the country to continue their studies.

Officers for 1961-62 were: Director, Nathaniel Riesenberg; Vice-Director, Larry Smith; Treasurer, Robert Kaufman; and Secretary, Harvey D. **Abramson.**

Officers for 1962-63 are: Director, **Shaul** Stahl; Vice-Director, Robert Blumenthal; Secretary, William Messing; and Treasurer, Edward Ross.

ALPHA OF LOUISIANA, Louisiana State University

The Louisiana Alpha Chapter held four meetings during the academic year 1961-62. The following papers were presented:

"The Existence of Fixed Points and Applications," by Dr. James **Keisler.**

"Mathematical Induction," by Dr. Haskell Cohen.
"Pathological Function," by Dr. T. Henry **Hildebrandt.**
"The Structure of the Real Number System," by Dr. Ronald C. **Bzoch.**
Louisiana Alpha held three initiations, one in the fall, spring, and summer. A total of forty students were initiated into the Chapter.

The Annual Honors Examination Awards were presented, at the University's Annual Honors Day Convocation, to the following: **Freshmen** Award to Daniel Elven Jones, and senior award to Charles Sparks Rees.

Officers for 1961-62 were: Director, Kenneth Glen Freeman; Vice-Director, DeWitt Lee Sumners; Secretary, Claire Fasullo; Treasurer, Jeffrey B. **Fariss;** Faculty Advisor, Dr. Haskell Cohen; and Corresponding Secretary, Dr. Houston T. Karnes.

Officers for 1962-63 are: Director, **DeWitt** L. Sumners; Vice-Director, Donald Roy Cowsar; Secretary, Kathleen Dolese; Treasurer, Harold **Reiter;** Faculty Advisor, Dr. Haskell Cohen; and Corresponding Secretary, Dr. Houston T. Karnes.

GAMMA OF LOUISIANA, Tulane University

The Louisiana Gamma Chapter was installed on November 27, 1961, and held five meetings during the year. The Chapter was installed by the Director General, Dr. J. Sutherland Frame. His installation paper was "Continued Fractions." At the installation dinner Dr. Frame spoke on "The History of Pi Mu Epsilon."

During the balance of the year four meetings were held with the following papers being presented:
"The Axiom of Choice," by Dr. G. S. Young.
"**Packings** of the Plane," by Dr. **A.** C. Woods.
"The Bieberbach Conjecture," by Dr. A. A. **Armendariz.**
"A Set Similar to the Cantor Set," by Dr. Bruce **Treybig.**
Seven new members were initiated into the Chapter at the spring initiation

Officers for 1961-62 were: Director, George W. Tiller, Vice-Director, Robert **E. Bonini;** Secretary, Sylvia A. **Ibele;** and Treasurer, Charles R. Blackburn, II.

Officers for 1962-63 are: Director, Henry W. **Frantz;** Vice-Director and Treasurer, Donald E. **Ramirez;** and Secretary, Patricia **Merkel.**

ALPHA OF NORTH CAROLINA, Duke University

The North Carolina Alpha Chapter held two meetings during the 1961-62 academic year. One a business meeting and the other the annual initiation **The** initiation address, "Continuous Functions," was given by Professor **F. G. Dressel.** Five students were initiated.

Officers for 1962-63 are: Director, James M. White; Vice-Director, Robert Chapman **Newman;** Secretary, Robert E. Smith; and Treasurer, Dabney W. Townsend, Jr.

EPSILON OF OHIO, Kent State University

The Ohio Epsilon Chapter held three meetings during the academic year 1961-62. At the annual initiation banquet on April 11, 1962, Professor Earle Bush, Head of the Department of Mathematics at Kent State University spoke on "What Is Mathematics?" Twenty-two members were initiated.

Film's shown at the two business meetings were: *The Earliest Numbers* and *Minute-Men, Missles, and Mission.*

Miss Vera Melinda Chapman received the Pi Mu Epsilon award at the annual Honors Day assembly. She was awarded a plaque and a check for $40.

Officers for 1962-63 are: Director, Lois Wilson; Vice-Director, James Weaver; Secretary, Barbara Grills; and Treasurer, Richard Schooley.

BETA OF NORTH CAROLINA, University of North Carolina

The North Carolina Beta Chapter held five meetings during the academic year 1961-62. The following papers were presented:
"Use of the Mathematics-Physics Library," by Dr. A. T. Brauer.

"Some Topics in Integration," by Dr. W. M. **Whyburn.**
"Infinite Processes," by Dr. F. B. Jones.
Nineteen new members were initiated into the Chapter during the year.

Officers for 1961-62 were: Director, Albert Deal; Vice-Director, Clifton **Whyburn;** Secretary, Sandra Ness; Treasurer, Warren Boe.

ALPHA OF NEBRASKA, University of Nebraska

The Nebraska Alpha Chapter held seven meetings during the academic year 1961-62. The following talks were given:
"Can Mathematicians Know Anything; If So, What?" by Professor Dewey.
"Tunnel **Diode,"** by David Gustavson.
"Telemetering of Physiological Responses of Athletes," by Dr. Rose.
Seventeen new members were initiated into the Chapter at the fall initiation and thirty-five were initiated at the spring initiation.

Officers for 1961-62 were: Director, Larry **Dornhoff;** Vice-Director, David Bliss; Secretary, William T. White; Treasurer, Richard Altrock; Faculty Advisor, Dr. Hubert **Hunzeber.**

Officers for 1962-63 are: Director, Jon **Froemke;** Vice-Director, Stephen Lange; Secretary, Robert **Ladd;** Treasurer, Ken Chatfield; Faculty Advisor, Dr. John **Kimber,** Jr.

BETA OF VIRGINIA, Virginia Polytechnic Institute

The Virginia Beta Chapter held eight meetings during the academic year 1961-62. The following papers were presented:
"Continued Fractions," by Dr. J. Sutherland Frame, Director-General of Pi Mu Epsilon.
"**Riemann** Functions and Their Applications to the Solution of Initial Value Problems in Fluid Dynamics," by Dr. Tom Chang.
"Using a Digital Computer to Obtain Bounds for the Solution of Certain Problems," by Dr. Walter S. Snyder.
"Matrix and Metrics," by Dr. L. B. **Rall.**

Officers for 1961-62 were: Director, Roger Flora; Vice-Director, Robert **Hanson;** Secretary, Janet **Yates;** Treasurer, Fred Patterson.

BETA OF OREGON, Oregon State University

The Oregon Beta Chapter held three meetings during the academic year 1961-62. No papers were presented at these meetings since the colloquium meetings of the mathematics department as a whole are available to the members of this chapter.

Social activities included a picnic during the fall term and the Initiation Banquet on May 22 at which Mr. David Johnson spoke on the subject of network flow.

A freshman-sophomore competition was held on March 26. The first prize of $50 was awarded to Stephen P. Ogard and the second prize of $30 to Gary J. Ford. The four students who received honorable mention and a book were Thomas L. Mundres, Vasilios Papakonstantinou, John **E.** Ferguson, and Janet Allison Approximately 35 students took the examination.

Officers for 1961-62 were: Director, John J. **Kohfeld;** Vice-Director, Botond G. Eross; Secretary, Betty Kvarda; Corresponding Secretary-Treasurer, Dr. **A.** R. Poole.

Director for 1962-63 will be Botond G. Eross. Other officers will be elected during the fall term.

BETA OF OKLAHOMA, Oklahoma State University

The Oklahoma Beta Chapter held fourteen meetings during the **1961-62** academic year. The following papers were presented:
"Experiences in Europe," by Professor R. B. Deal.
"Matrix of a Magic Square," by Gene **Sturm.**
"**Applications** of Boolean Algebra to Logic," by Professor R. W. Gibson.
"An Astronomer Looks at Space Travel," by Professor H. S. Mendenhall.
"Orientation," by Louis De **Noya.**

'Finite Differences,'' by Professor Robert **Hultquist.**
''A Topic from Physics,'' by Professor H. P. **Hotz.**
''Fixed Point Theorems,'' by Professor O. H. Hamilton.
''Inverse Ratio System of Counting **Ballots,''** by Professor Robert **W.** Gibson
''An Extension of Pascal's Triangle,'' by Jimmie **Lakin.**
''Perfect Numbers'' by Mary Johnson.
' A Concept of Time for Scientists,'' by Mr. Savoe Lottenville.

At the annual banquet on May 4, 1962, Professor L. Wayne Johnson presented the Freshman Mathematics Award to Lynn Carpenter. The banquet address was given by Professor R. B. Deal whose topic was, ''A La **Sorbonne.''**

Officers for 1961-62 were: Director, Gene **Sturm;** Vice-Director, Stuart Reeves; Secretaries, Mary Lou **Thurman** and Linda Priest West; Treasurer, Dale **Keairns;** and Faculty Advisor, Professor John E. Hoffman.

Officers for 1962-63 are: Director, Jimmie **Lakin;** Vice-Director, Joseph S. Greene; Secretary, Mary Ann Smith; Treasurer, Bruce Edgar; and Faculty Advisor, Professor John E. Hoffman.

ALPHA OF ALABAMA, University of Alabama

The Alabama Alpha Chapter held five meetings during the academic year 1961-62. The following papers were presented:
''The Seven Bridges of **Königsberg,''** by Dr. Charles Neville Maxwell.
''Non-Interacting Control Systems,'' by Dr. O. R. **Ainsworth.**
''Numerical Solutions for Differential Equations,'' by Dr. Walter L. Wilson.
'Philosophy of Mathematics,'' by Mr. George W. Roberts.

Dr. Clark, Assistant Dean of the College of Arts and Sciences, gave the annual banquet address; and the annual spring picnic was held in **Mound-**ville, Alabama.

Two initiations were held, in the fall and spring, and a total of eighty-six students were initiated into the Chapter.

Officers for **1962-63** are: Director, Dieter **Pukatzki;** Vice-Director, **J. Z. Higgs;** Secretary, Patricia Lucas; Treasurer, Nancy Charles Jones; Social Co-Chairmen, **Adonice** Hereford and James **Dixon;** and Faculty Advisor, Dr. Henry Miller.

ZETA OF OHIO, University of Dayton

The Ohio Zeta Chapter held nine meetings during the academic year 1961-62. The following papers were presented:
''Derivatives of Composite Functions,'' by Mr. Thomas Grilliot.
''Iterations of the Exponential Function,'' by Professor **McIntyre.**
''Research and Mathematics,'' by Professor Buck.
''Structure of Mathematics and Convex Sets,'' by Professor **Pettis.**
''Applications of Differential Geometry to Hydrodynamics,'' by Professor **Mishra.**
''Calculus of Variations,'' by Professor **Cesari.**
''Problems in General Geometrical Dynamics,'' by Professor **Hlavaty.**
''Observations on Recent Trends in School and College Mathematics,'' by Professor Reingold.

Mr. David Schweickart, a recent initiate, was named as the sophomore who had excelled most in mathematics and was awarded the two volumes of ''Differential and Integral Calculus'' by Courant.

Officers for 1962-63 are: Director. Mr. Thomas Grilliot; Vice-Director, Mr. David Van **Hausen;** Secretary-Treasurer, Mr. Max **Gruendl.**

GAMMA OF NORTH CAROLINA, North Carolina State College

The North Carolina Gamma Chapter held fourteen meetings during the 1961-62 academic year. The following papers were presented:
''The Law of Growth and Decay,'' by Dr. John **W.** Cell, Head, Department of Mathematics.
''Applied Mathematicians and What They Do,'' by Dr. Horace Trent, Ballistic Research Laboratories, Washington
''The Changing Undergraduate Curriculum,'' by Dr. R. Creighton Buck, Chairman, Committee on the Undergraduate Program in Mathematics, University of Wisconsin.
''The Rocket Research Project at North Carolina State College,'' by Dr. R. C. Bullock.
''A Method of Solving a System of Differential Equations,'' by Mr. Jafar **Hoomani.**

Officers for 1961-62 were: Director, Walter B. **Cummings:** Vice-Director, Betty G. Harris; Secretary-Treasurer, Philip Nanzetta; and Faculty Adviser, Dr. James B. Wilson.

Officers for 1962-63 are: Director. Thomas H. Banks; Vice-Director, William S. **Guion;** Secretary-Treasurer, Richard Shachtman; and Faculty Adviser, Dr. James B. Wilson

GAMMA OF WASHINGTON, Seattle University

The Washington Gamma Chapter held four meetings during the academic year 1961-62. The following papers were presented:
''Orthogonal Polynomials,'' by Dr. Theodore Chihara.
''Conformal Mappings,'' by Dr. William **Woolf,** University of Washington
'Famous Problems, Solved and Unsolved,'' by Dr. R. H. Bing, University of Wisconsin.
''Mathematical Curiosities,'' by Dr. R. H. Bing.

Eleven students were initiated into the Chapter in two initiations held during the year.

Officers for 1961-62 were: Director, Gary Haggard; Secretary-Treasurer, Mary Ann Hoare; and Faculty Advisor, Dr. Theodore Chihara.

MU OF NEW YORK, Yeshiva University

The New York Mu Chapter held several meetings during the academic year 1961-62. At the final meeting, the following were elected officers for 1962-63: Director, Benjamin **Volk;** Vice-Director, Martin **Braun;** and Secretary-Treasurer, Robert **Reinerman.**

ALPHA OF OKLAHOMA, University of Oklahoma

The Oklahoma Alpha Chapter held eight meetings during the academic year 1961-62. A paper was presented at each meeting. Dr. N. A. Court gave the annual banquet address. His subject was: ''What is Mathematics?'' Thirteen students were initiated during the year.

Officers for 1962-63 are: Director, Earl **LaFon;** Vice-Director, Leo Pratte; Secretary-Treasurer, Maureen Pratte; Faculty Sponsor, Dr. Allen Davis; and Faculty Correspondent, Dr. Dora **McFarland.**

BETA OF KANSAS, Kansas State University

The Kansas Beta Chapter held five meetings during the academic year 1961-62. The following papers were presented:
''Simulation of Fractional Derivative and Integral Operators on an **Analog-**Computer,'' by Mr. Gordon E. **Carlson.**
''Bernoulli Numbers and Bernoulli Polynomials,'' by Professor Paul J. **McCarthy,** University of Kansas.
'The Elastic Bar Variational Problem.'' by Professor Raville. Head. **Department** of Applied Mechanics.
''Rational Function Approximation.'' by Dr. Henry Thacher, **Argonne** National Laboratory.
''Recent Developments at Kansas State University,'' by Dean Paul Young.

Thirty-seven members were initiated into the Chapter at the spring initiation.

Officers for 1962-63 are: Director, Neal Poland; Vice-Director, Robert Crank, Secretary, Michael Miller; and Treasurer, William Stamey.

ALPHA OF KENTUCKY, University of Kentucky

The Kentucky Alpha Chapter held eight meetings during the academic year 1961-62. The following papers were presented:

"Mathematics. Computers, and Business," by Dr. J. B. Cornelison.
"Mathematicians and the Computer Revolution," by Dr. Silvio **Navarro.**

An annual banquet was held with Dr. Wendell De Marcus of the Department of Physics giving the address. Dr. De Marcus' topic for the banquet address was, "The Peeled Earth."

Winner of the Pi Mu Epsilon Distinguished Mathematician Book Award was Thomas **Steadman Bagby.** Jim Caveny received the Pi Mu Epsilon Key Award for the best mathematical content seminar paper with **the best** presentation

Five members of the chapter have received fellowships to aid in their continued studies.

Officers for 1961-62 were: Director, John Pfaltzgraff; Vice-Director, Clifford **Swauger;** Treasurer, **Lael** Kinch; Secretary, Evelyn Rupard; Librarian, Jim Caveny; and Faculty Advisor, Dr. T. J. **Pignani.**

Officers for 1962-63 are: Director, Jackson Lackey; Vice-Director, Evelyn Rupard; Treasurer, Adelbert Roark; Secretary, Mary E. Logan; Librarian, James Miller; and Faculty Advisor, Dr. T. J. **Pignani.**

KAPPA OF NEW YORK, Rensselaer Polytechnic Institute

The New York Kappa Chapter held four meetings during the academic year 1961-62. At the annual banquet Dr. Richard C. **DiPrima** spoke on "The Mathematician in Industry and in the Academic World."

Twelve members were initiated into the Chapter at the fall and spring initiations.

A student-faculty lecture series was established by the Chapter and two lectures were presented in this program.

Officers for 1962-63 are: Director, Richard Mateosian; Vice-Director, Larry Levine; and Secretary-Treasurer. Howard Kushner.

ALPHA OF NEW YORK, Syracuse University

The New York Alpha Chapter held six meetings during the academic year 1961-62. The following papers were presented:

"Proofs of Irrationality," by Dr. Albert Edrei.
"Topology and the Imagination," by Dr. Mark Mahowald.
"Opportunities **in** Mathematics," by Dr. Erik **Hemmingsen.**

In April the annual banquet was held. Dr. Clyde **Hardin** of the Department of Philosophy gave the banquet address. His topic was. "Can Machines **Think?"** At the banquet, twenty-one students were initiated into the Chapter.

In March the third annual mathematics contest for high school seniors of the Central New York area was sponsored and prepared by the Chapter. Syracuse University donated a full tuition scholarship for one year for the winner and the Chapter purchased other prizes.

Officers for 1961-62 were: Director, Donald V. Davies; Vice-Director, Bradley Fullager; Secretaries, Linda Sullivan and Marilyn **Meinhardt;** and Treasurer, Donald A. Lutz.

Officers for 1962-63 are: Director, Lee Bryant; Vice-Director, David **Kahn;** Secretaries, Leonora **Zebkiw** and Linda **Serednicky;** Treasurer, Adrian Warntz; Faculty Advisor, Professor Mark Mahowald; and Faculty Correspondent, Professor Nancy Cole.

ALPHA OF ARIZONA, University of Arizona

The Arizona Alpha Chapter held eight meetings during the academic year 1961-62. The following papers were presented:

"The Indian Mathematician **Ramanujan,"** by Dr. L. J. **Mordell.**
"Fibonacci Sequences," by Mr. **Charles Haskell.**
"The Area Theorem," by Dr. L. M Milne-Thompson.
"Eigenvalues of the **Sturm-Louiville** System," by Mr. Joseph Bronder.

Membership requirements were raised during the year and the practice of holding two initiations instead of one was begun. The fall semester's initiation was held at a banquet on January 4, 1962. Dr. John Webb gave the banquet address, "The Mathematician in Society.',

Officers for 1962-63 are: Director, Bob **DeVore** and Secretary-Treasurer, John Bunch.

ALPHA OF MONTANA, Montana State University

The Montana Alpha Chapter held twelve meetings during the academic **year** 1961-62. The following papers were presented:

"What to do About J $[\sqrt{-5}]$?" by Dr. William Ballard.
"Riemann Surfaces," by Mrs. Hilda **Haltz.**
"Arezla's Generalized Theorem," by Mr. Richard **NanKervis.**
"Uncertainty and Probability," by Mr. George Trickey.
"Number Theoretic Functions," by Mr. Allen Luedecke.
"Waring's Problem," by Mr. Fred **DeMarinis.**
"Buffon's Needle Problem," by Mr. Richard Konesky.
'Orthonormal Sets," by Mr. Harry Bauer.
"Dimensional Analysis," by Mr. Edward **Kopitzke.**
"Rain on the Roof," by Mr. George **McRae.**
"Two Parameter Eigenvalue Problems," by Dr. Felix **Arscott.**
"Topological Surfaces," by Dr. R. H. **Bing.**

Montana Alpha presented awards in the form of books to Mr. Barry Davis - outstanding student in undergraduate mathematics and Mr. John **Ulvila** - outstanding student in undergraduate physics. The Chapter also contributed ***$50*** for prize money for the 1962 Montana Science Fair. Winners, and the schools they represented, were each awarded books.

Officers for 1961-62 were: Director, Allen Luedecke; Vice-Director, George Trickey; and Secretary-Treasurer, Robert **Svehla.**

ALPHA OF NEW MEXICO, New Mexico State University

The New Mexico Alpha **Chapter** held nine meetings during the academic year 1961-62. The following papers were presented:

"Pontrijagin Duality for Semigroups," by Mr. Charles Austin, University of Washington.
"A Topic **from** Statistics," by Dr. Rudolph Borges, University of Cologne.
"Summability," by Mr. J. P. **Brannen, University** of Texas.
"Modem Modem Algebra," by Professor **S.** Eilenberg, Columbia University.
'The Riemann **Hypothesis** and Space **Communication,"** by E. C. **Posner,** Jet **Propulsion Laboratory.**
"Generalized Information Theory," by **N. Scarritt, Purdue** University.
"Statistical Metric Spaces," by Professor B. **Schweizer,** University of Arizona.
"Sheaves, Germs, and Lattices," by Professor John D. Thomas.
"Dedekind Rings and Linear Algebra," by Professor Robert **J.** Wisner, Michigan State University, Oakland.
"An Application of Finite Induction to Number Theory," by Professor Robert J. Wisner,

Officers for 1961-62 were: Director, Carol L. Peercy; Vice-Director, Edmund J. Peake, Jr.; Secretary-Treasurer, William L. Caudle. Professor Seymour Goldbert, chapter advisor and permanent faculty correspondent, is on leave of absence during the year 1962-63. **Consequently,** Professor **John** D. Thomas will assume these duties.

LAMBDA OF NEW YORK, Manhattan College

The New York Lambda Chapter **held** thirteen meetings during the 1961-62 academic year. The following papers were presented:

"The Mathematics of Computer Programming," by Mr. John **Morrissey,** IBM.
"The **Hierarchy** of Geometry," by Mr. Nicholas De **Lillo, Fordham University.**
"The Actuarial Profession," by Mr. Robert Johansen, F. **S.** A.
"Equivalence Relations," by Mr. Donald **McCarthy,** New York University.
"Orthogonal Function," by Charles Weber.
'Generating Functions," by Jeremiah Kelly.
"Introduction to Infinite Products," by Stanley S. Leory.
'Theory of Numbers," by **Whitney S.** Harris.

Twelve members were initiated into the Chapter at the initiation held in the spring.

Three members of the chapter, Charles Weber, Frank J. Gordon, and John Stout, represented Manhattan College in the Putnam Mathematical Contest and ranked 86th out of the 165 teams entered into the contest.

Five members have received awards which will aid in their continuing studies.

Officers for 1961-62 were: Director, Jeremiah Kelly; Vice-Director, Stanley S. Leroy; and Secretary-Treasurer, Harry J. Neylan.

Officers for 1962-63 are: Director, Thomas G. Walsh; Vice-Director, Gerald Silva; and Secretary-Treasurer, John Stout.

ALPHA OF VIRGINIA, University of Richmond

The Virginia Alpha Chapter held six meetings during the academic year 1961-62. The following papers were presented:

"On Decimal Fractions," by Professor Harley Stafford.

"Programming for Digital Computers," by Professor Frederick Schmidt, Medical College of Virginia.

"A Model for the Real Number System," by Barbara Sue Oglesby.

"The Axiom of Choice," by Kent Wright.

The following awards were issued by the Chapter:

Freshman Mathematics Examination - First Prize ($10), John Bsiley; Second Prize ($5), Thomas Hicks. Sophomore Mathematics Examination - First Prize ($7.50 each), a tie between Van Bowen and Michael Kusheba.

The James D. Crump Prize, a University award for excellence in mathematics, was won by Charlotte Adams.

Officers for 1961-62 were: Director, Paul Cohen; Vice-Director, Alice Hall; Secretary, Charlotte Adams; and Treasurer, Harold Smith.

Officers for 1962-63 are: Director, Kay Koontz; Vice-Director, William R. Tolbert; Secretary, Cecelia Stiff; Treasurer, Hans Carter; Corresponding Secretary, E. Sherman Grable; and Faculty Advisor, H. Pearce Atkins.

ALPHA OF FLORIDA, University of Miami

The Florida Alpha Chapter held eleven meetings during the academic year 1961-62. The following papers were presented:

"Mathematics, Science of Game?" by Professor L Rosenbaum.

"The Revolution in Geometry," by Professor F. Borges.

"Introduction to Some Recent Concepts in Topology," by Dr. Morton L. Curtis.

"Application of Modular Arithmetic to Computing Machines," by Dr. H. Aiken.

"Complex Numbers and Quaternions," by Dr. Herman Meyer.

"How to Talk to a Computer," by J. B. Kaplan

At the Initiation Banquet Dr. Cesare Emiliani of the University of Miami Institute of Marine Sciences gave the address. His topic was, "The Possibility of Extraterrestial Life as Evidenced by Certain Types of Meteorites." Thirty-two new members were initiated this year.

A scroll was presented to Mrs. Georgia Del Franco, Faculty Correspondent, who is a charter member of the Florida Alpha Chapter. In addition, winners of the Pi Mu Epsilon Mathematics Contest were: first prize, James W. Rose and second prize, Paul Brown

Officers for 1961-62 were: Director, Lawrence Hawkins; Vice-Director, William Fienning; Secretary-Treasurer, Gloria Cashin; and Faculty Advisor, Miss Patricia Elliott.

Officers for 1962-63 are: Director, Gloria Cashin; Vice-Director, Stephen Love; Secretary-Treasurer, Sofia Pappatheodorou; and Faculty Advisor, J. B. Kaplan.

INITIATES

ALABAMA ALPHA, University of Alabama (Spring, 1962)

Martha F. Alexander
Robert D. Alien
Hollis P. Behannon
Bettye A. Blake
James A. Brasher
Patricia A. Bruening
James L. Chesser
Harold L. Daniel
William A. Dark
Bernard Digiorgio
Eleanor J. Dudley
Judith K. Dunn
Ann D. Fite
Olney R. Fortier
William L. Gamble
Carolyn A. Gilchrist
Laura Gonzales
James A. Guin
Robert W. Gunderson
Adonice C. Hereford
John T. Hubbard, Jr.
Eddit T. Hunt
Jane S. Jones
Jetty V. Lindsey
William T. Mauldin
James A. Maxwell
David N. McNelis
Charles G. Montgomery
Johonna Nichol
Gregory T. Ogden
Jimmy Porter
Charles Rampacek
Lynn H. Rice
James E. Simmons
Kathie Simon
Thomas C. Smitherman
Donald Thompson
John D. Warmbrod
James W. Wiggins
Clifton T. Windham

ALABAMA BETA, Auburn University (May 10, 1962)

Hubert R. Adkins
Robert S. Ballard
Robert F. Baits
Johney E. Burkhalter
William H. Butler
Don Chambless
Floyd L. Currie
Harry L. Defferbach
Kay Finncy
Sandra Gray
Ann Grogan
Phillip R. Henderson
Raymon A. Henton
Mary E. Hinton
Stewart V. Horn
Azalia A. Osborn
James R. Pitts
Gerald A. Pounds
Athanasios Prakouras
Naomi Robbins
Franke A. Rusche
Edwin W. Smith
Thomas H. Springfield
Lawrence H. Stone
Jetty F. Thomas
Martha S. Thomas
Francis E. Watson
John P. Weidner
Jerry F. Williams
Joe E. Young

ARIZONA ALPHA, University of Arizona (June 4, 1962)

John Louis Bunch
Raphael Finkelstein
Helen Gin
Bernard A. Fischer

ARKANSAS ALPHA, University of Arkansas (Match 19, 1962)

Donald R. Allen
Robert Arlington
Mary K. Beavers
Nancy W. Brown
William D. Bushmiaer
Webster T. Gotten
Bryce E. Curtsinger
Ronald E. Eddy
Robert O. Fisher
Melvin V. Foster
Rebecca A. Frazier
John K. Harris
Terry J. Henley
Ronald E. Hill
Robert L. Hudson
James T. Karam
Marwin K. Kemp
Joe B. Locke
Judy M. Loux
Rex A. Martin
Phyllis G. McFarland
Kim L. Mitchell
Jetty K. Ott
George E. Rouse
Randall C. Stephens
Jack B. Swift
Phillip A. Terry
George K. Wallace
Robert J. Welborn
Leonard A. Wiggins
Edward G. Woods

CALIFORNIA ALPHA, University of California, Los Angeles (February 4, 1962)

Edwin S. Beckenbach
Sorrell Berman
James R. Bock
Fook Eng
Robert J. Engert
Motley A. Feldstein
Allesandro Figa-Talamanca
Arthur P. Gittleman
Robert Gold
Theodore Gold
John S. Lane
Joseph Motzkin
Howard Ritea
Bernard Russo
Howard B. Vein

CALIFORNIA GAMMA, Sacramento State College (Fall, 1961)

James Chrislock
Ann Cornelius
Eric Frerking
Charles Hagopian
Byron Hendrix
Barthel W. Huff
Evelyn Larsen
Ray McAfee
Cynthia Speed

DISTRICT of COLUMBIA ALPHA, Howard University (May 19. 1962)

Anjean B. Carter
Basil Livingston Cleare
Willie E. Cook, Jr.
Oscar H. Criner
Eugene M. DeLoath
Robert Gamble
Ray C. Titus
William Gee
Sandra Ann Gittens
James Edward Joseph, Jr.

FLORIDA ALPHA, University of Miami (May 12. 1962)

Irving Abel
Richard H. Ault
John M. Blackstock
Gerald A. Bottorff
Everett H. Boyd
Alton T. Butson
John W Cooper
William L. Davis, Jr.
James Philip Dean
John E. Dennis, Jr.
Raymond F. Dickman
Edwin Duda
Sue Edwards
Delvis A. Fernandez
Jerrold Gans
Robert J. German
Beryle A. Greenberg
Harvey J. Greenberg
Giacomo Grippo
Barbara A. Hopf
Stephen F. Love
William S. Moore, III
Sofia A. Pappatheodorou
James G. Pardew
Fred Perlove
Leonard R. Rubin
Eugene Sadowski
Victor Sung
Marinell Thompson
Manuel Villar
Thomas J. Walend
Edward R. Young

FLORIDA BETA, Florida State University (May 15, 1962)

Lee H. Armstrong
Cavin O. Cotey
David P. Hayes
Martin N. Heinezer
Wade T. Macey
Beverly A. Martin
Stanley E. Payne
Chris B. Schaufele
Harriet H. Sibley
Kurt A. Snover
Janace A. Speckman
Daniel S. Yates

GEORGE ALPHA, University of Georgia (March 7, 1962)

Alan Atwood
Tommy R. Dell
John Goode
Robert B. Hafer
Albert G. Horrocks
Larry K. Johnson
Hillary L. Kitchens
Linda J. Sutton
Susan E. Tilghman

GEORGIA BETA, Georgia Institute of Technology (May 20, 1962)

Hagood Bellinger
Gary D. Bent
Donald G. Bodnar
David L. Brown
Milton E. Cram
K. Bruce Erickson
James R. Gard
William C. Lineberger
Edward B. Saff
Sanford M. Wiener
John D. Wright
Mehdi S. Zarghamee

ILLINOIS ALPHA, University of Illinois (May 2, 1962)

Carol S. Abe
Muhammad S. AbuSalih
M. Edward Borasky
Milo F. Byrn
Thomas A. Bums
Shu-Park Chan
Herbert Y. Chang
Kenneth R. Conklin
Charles G. Denlinger
Donald J. DeSmet
John H. Esbin, Jr.
Kenneth E. Evans, Jr.
Robert E. Gaines
Paul M. Grabarkewitz
Frank D. Grosshans
Donald U. Gubser
Arthur W Hammar
Robert M. Jones
Robert J. Kansky
Jose Katz
James J. Kelleher
Robert G. Lange
Thomas M. Latta
Ralph A. Liguori
Lawson Lobb
Bernadette G. Londak
Joseph B. Miles
Lois E. Minning
David D. Morrison
Billy R. Nail
Andrew R. Neureuther
Carol M. Perersen
Edward F. Rittenhouse
Alexander P. Stone
Stanley L. Urwiller
Zalman Usiskin
Henry Waldman
William Weitzman
Carroll O. Wilde
Bing Kuen Wong
Henderson C. H. Yang

ILLINOIS BETA, Northwestern University (November, 1962)

Vernon L. Baily
Larry W Broberg
Roger L. Cooke
Lee A. Egherman
Stephen P. Fox
Donald R. Frederick
Alyce L. Gagosian
Robert L. Gerlach
Roland W Gubisch
William J. Hankley
Charles F. Hepner
Melvyn E. Huff
Harvey R. Huttas
Patricia A. Johnson
Robert J. Kilian
Sara E. King
David E. Kullman
John B. McColly
Dennis J. Mueller
Carol Muse
Richard Nielsen
Robert L. Obenchain
Deane M. Peterson
Robert Rice
Jeffrey R. Sampson
John L. Schofill, Jr.
Sherman M. Shand
Richard A. Soderberg
William F. Stasior
Robert Streitmatter
Robert L. Ward

ILLINOIS DELTA, Southern Illinois University (May 22, 1962)

Allen R. Campbell
Wilbur H. Clark
Ralph Czerwinski
Lenard A. Defend
Richard Fulkerson
Marie A. Hughes
Carolyn J. Jarick
David W Kammler
Theodore Kramme
Barbara K. McMillan
David C. Mueth
Stanley B. Poe
Mary C. Scott
Charles T. Wright, Jr.

IOWA ALPHA, Iowa State University (Spring, 1962)

Charlotte Louise Ashbaugh
Geoffrey S. Boehm
Susan Chamberlin
Lloyd Craig Davis
Henri Feiner
David Leroy Hench
John H. Hoper
Richard Ewers Horron
David Wayne Jachson
Howard Jackson
Gene A. Kemper
David Kennison
Mads Ledet
Allan Theodore Leffler, II
Ronald Wilson Moses, Jr.
Larry L. Orr
Robert Dennis Pedersen
R. Dean Riess
Steven R. Ritland
Richard E. Robinson
Marilyn Russell
Donald E. Schmidt
Dennis Paul Swain
Curran S. Swift
James R. Veale
James Brian Wahrenbmck

KANSAS ALPHA, University of Kansas (April 27, 1962)

Harold W Breedlove
Edwin W Buchert
Emanuel G. Calys
Charles R. Combrink
Marvin E. Donaldson
Roger Eggerling
David L. Erickson
Robert H. Feitz
Donald L. Foster
John B. Johnston
James P. Kirk
Kenneth G. Klenke
David G. Lash
Floyd D. Lee
Thomas W Loewen
Michael C. Mackey
Charles D. Marshall II
Philip N. Merritt
Richard A. Moore
Jean M. O'Dell
Kenny L. Peterson
Frederick Pilcher
Dieter A. Reetz
Harold Schick
David C. Scott
Jeanne L. Sebaugh
Sara Y. Simcoe
Lee M. Sonneborn
Urs P. Wild
Fred L. Wilson

KANSAS BETA, Kansas State University (May 22, 1962)

Frederic C. Appl
Billy H. Bailey
Gary A. Bogar
Elmer E. Branstitter
James D. Callen
Kenneth H. Carpenter
Curt H. Chadwick
Richard D. Chelikowsky
Kent Crawford
William Davis
Judith A. Dreiling
Mark J. Dreiling
Gerald W Ebker
Margaret F. Flynt
Mohan L. Garg
Everett E. Haft
John C. Hassler
Thomas M. Keegan
Harry D. Knostman
Dale D. Koelling
Samuel L. Lesseig
Bill Livesay
Francis E. Masat
Ulrich Mathis
Judith A. Mawdsley
Charles H. Murish
John H. Nichols
Larry D. Noble
Chia-ven Pao
Jerry W Pence
David Poon
Gary S. Spencer
William W St. Cyr
John E. Tuecke
Hugh S. Walker
Cha Ho Wang
Wayne L. Woodworrh
Jerald J. Wray
Leroy J. Yock

KANSAS GAMMA, University of Wichita (May 4, 1962)

Robert L. Blumenshine
Norbert W. Deneke
Ronald E. Dutton
Elmer A. Hoyer
James O. Matous
Michael R. Mendenhall
Paul J. Schwindt
Charles Thomas Snyder
Donald H. Wetmore
Frank L. Wright

KENTUCKY ALPHA, University of Kentucky (May 10. 1962)

Francis R. Clarke
Bradley B. Cox
James E. Miller
Betty B. Robinson
Saeed Salehi
William C. Setzer

LOUISIANA ALPHA, Louisiana State University (May 16, 1962)

Charles F. Blank
Maunsell W. Brousseau III
Edward E. Counce, Jr.
Donald R. Cowsar
Kathleen Dolese
Kenneth W. Eiswirth
Waker H. Grant
Edward J. Pisa
Richard S. Thomason

LOUISIANA ALPHA, Louisiana State University (August 3, 1962)

Sr. Mary Sylvester DeConge
Charlotte Eloquin
Margaret Austine Hunter
Georgiana Mary Landry
Inez Chappell
Charles S. Van Arsdall
Virginia Louise Williams
Joyce Lester Wilson

LOUISIANA BETA, Southern University (April 25, 1962)

James Anderson
Montrust Burrell
Leon Daughtry
Ulyssis Days
Chester Givens
Archie Harris
Colonel Johnson, Jr.
Kenneth Joseph
Norma J. Lewis
Kenneth Maloney
Doris Matthews
Ivan McGowan
Betty J. Neal
Willis Porter
Stella Roberson
Herbert Rolans
Merdis J. Taylor
Henry Thurman
Doris A. Williams
Vernon Williams
Austin Woolfolk

LOUISIANA GAMA, Tulane University (April 5, 1962)

Henry W. Frantz III
Lawrence M. Hanafy
Donald E. Ramirez
Fred L. Smith, Jr.
Call S. Weisman

MARYLAND ALPHA, University of Maryland (April 29. 1962)

Harry N. Bragg
Charles M. Eckert
Paul A. Gerhard
Ulrich Gerlach
Sallie A. Hartwood
Daniel M. Hyman
Barry Kaminsky
Nancy Loweth
Leo J. Mueller, Jr.
Ronald D. Pittle
Dickson Preston
Eleanor Schwartz
Sadegh Siahatgar
Nolan Wallach
William J. Wickless. Jr.
Wayne L. Milmot

MICHIGAN ALPHA, Michigan State University (March 1. 1962)

William Brewer
Jerry Chateau
Michael Cooper
William Graham
Jin-Sheng Huang
Richard Johnson
James MacKenzie
Kenneth Malich
Steve Onderwyzer
Carla Oviatt
Gerald Pacholke
Paul Pennock
Allan Petersen
Morteza Rahimi
Batty Smith
James Stewart
Douglas Strickland
Tom Tucker
Sandra Wilcox

MINNESOTA ALPHA, Carleton College (June, 1962)

Duane Edwin Anderson
Brace David
George Stanley Eugster
Alan Dale Fiala
William Tibbets Ford
William Russell Gage
Richard Earl Hammer
Douglas Ralph Jones
James Erling Johnson
Garry Robert Kampen
John M Karon
Stanley Lewis Klein
George Koehler
Frederick Wilbur Lott, III
Felicia Giare Oldfather
Jonathan Beach Skinner
Anthony Smith
William Sudman
Katherine Anne Wier

MISSOURI ALPHA, University of Missouri (May 1, 1962)

Conrad W. Bowers
Edward K. Bower
William A. Brock, III
Ernest Brockelmeyer
Charles R. Coe
John P. Creason
Ronald L. Cole
Richard L. Francis
Theodore J. Gibson
Jerome M. Ginden
Thomas G. Hallam
William Herder
Ronald L. Hollrah
William H. Jennings
Verlin Koper
Kathryn L. Kordes
Lynn Kuluva
Charles A. Leech, III
Fook Wah Leong
Steve Ligh
Mary A. Logan
Doris R. Long
Carl L. Ludwig
David O. Lambeth
Charles B. McLane
Martin J. Megeff
John L. Meyer
Kathy Mussman
Pamela Nett
Nancy L. Nitz
Robert F. Randall
Robert Ritenour
Robert M. Sandford
Norbert Schmidt
Norma Jo Smith
Randall W. Stone
Floyd G. Teaney
Richard D. Teaney
Ester I. Tichenor
David E. Tomlin
Mathukumalli Vidyasagar
Marvin Wolfmeyer
Farroll T. Wright
Robert E. Yorke
Sergio Lerda-Olberg

MISSOURI GAMMA, St. Louis University (April 11, 1962)

Noel J. Abkemeier
Raymond M. Albers
Patrick Argos
Virginia A. Arnoldy
Joseph H. Austin, Jr.
Robert Babione
Victor L. Badillo, S.J.
Charles J. Balsarotti
Helen M. Barren
Paul T. Bauer
S. Louise Beasley
John A. Beuchman
Claire M. Birkbeck
Gerald Charles Blausey
Jean M. Bordeaux
Charles J. Brez
Kathleen P. Brady
Patricia A. Brown
John P. Bufe, Jr.
Benjamin R. Bullock
St. M. L. Burk, O.P.
Sr. M. J. Carbonneau, R.S.M.
Charles P. Casey
Mary J. Chirpich
Dorothy Clark
Elizabeth A. Coerver
Thomas P. Comer
Ronald R. Conners
Sr. M. Coleman Conroy, O.S.F.
Major Ralph P. Corbell
John Cortina, S.J.
Jack Cronin
Ann Corrigan
Patrick Henry Crowe
Ruth A. David
Kosta M. Dedo
Earl E. Dee
Julia R. Deimund
William M. Denny
John M. Desloge
Donald F. Deutsch
Neil C. DeVries
Andrew J. Dufner, S.J.
Patricia J. Durse
Donald M. Eisel
Robert F. Emmett
Robert G. Erwin
ST. M. Marcelline Falk, C.P.S.
Fadlullah M. Farouq
Sr. M. Geraldine Farrant, S.S.J.
Paul F. Feldker
Thomas D. Fiorino
Sr. M. Carlita Fitzpatrick, R.S.M.
Gerald W. Folk
John F. Fox
Joan F. Franz
Edward E. Funke
Darell Gage
Daniel J. Gannon, S. J.
Juan M. Garcia, Jr.
Cherie Ann Gass
Owen Gleeson
Arthur F. Glusenkamp
Michael A. Grayson
ST. Amrosia Greiner, O.S.F
James J. Gummels
John B. Haack
John A. Haley, S.J.
St. M. deLourdes Hardesty, O.S. F.
Vincent M. Harmon
Anthony D. Harris
William H. Heidger
James A. Helwig
Thomas E. Henderson
Karen Ann Herbst
Fiances Hewitt
Gertrude T. Heyl
John T. Hogan
Edward J. Hoffman
Richard L. Holdener
Jetty L. Hollingsworth
Judy A. Hoog
John J. Horenkamp
Sr. Elizabeth M. Huber, B.B.M.
Jeanne H. Huesemann
Wayne L. Humphrey
Marion A. Joncich, S.J.
Sr. Martina Kalinosky
James L. Kappel
St. James M. Keezer, S.U.S.C.
Francis X. Ken
Joan E. Kessling
St. Dorothy Kiel, C. D.P.
ST. M. Fintan Killian, R.S.M.
Kenneth J. Kintz
Carol Koeppen
Orest Koropecky
Philip M. Krause
Joan L. Kristof

Annette **J.** Krygiel
Barbara **M.** Kuehne
Sr. Lois **M.** Lapeyre, D.C.
Frank A. Latuda
Sr. M. Basil **LeDuc,** **O.**S.D.
Vincent K. Lee, S.J.
Joan L. **Leiper**
Joan **M.** Leysaght
John H. **Liebe**
John **Chian** Wun Linn
Ronald D. Luczak
Hubert **J.** Ludwig
Nancy L. **M. Mallonee**
John E. Mansfield, S.J.
Donald **J. Manson,** S.J.
Madge T. Mao
Margo T. Mao
St. DePaul Massoni, D. C.
John **J.** Matejcic
Matthew N. **McKay**
Mark D. **McKenzie,** S.J.
Michaela K. **McKittrick**
John G. Weber
James G. Miller
Mary D. Montie
Mary E. Murphy
Sara K. Olivier
ST. **M.** Patrick **O'Tolle,** S.S.N. D.
Joseph M. Paikeday
John **M.** Piet
Mary K. **Pisarek**
John D. Pope
Thomas **J.** Quinn, S.J.
Ronald **M.** Reap
Thomas **C. Rochow**
Roy W. Robinson
Judy E. Ross
Earl **J.** Scalet
David G. Schmidt.
Raymond **J.** Schmitt
R. Gary Schouborg, S.J.
George W. Schroeder
James C. Schuff
Juan Sobrino, S.J.
Laurence **J. Sowash**
Jerome **E. Steinke**
Dennis E. **Starbuck**
Sr. M. Barbara **Stastny, OSF**
Joyce **Stratman**
Charles D. Stubbs
Peter **M. Szucs**
Frederick **M.** Tasch
Margaret **Thiel**
Mary E. Thompson
John T. Thompson, S.J.
Anthony P. **Tieber**
Joseph A. Tikvart
Mother **M.** Patricia
Thro, **RSCJ**
Dilawar F. Uthman
Guillermo Van Hoorde
M. Virginia **Vanice**
Michael F. Vezeau
Wynn A. Volkett
Francis **J.** Willy, S.J.
Margaret L. Wolf
Donald A. Wuebbels
Zuhair **Aziz** Yacu
Anthony J. **Zappanti**
Raymond **W.** Zavislak
Eugene A. Zerega
Gaylord Zimmerman, Jr.
John H. **Zupez,** S.J.

MONTANA ALPHA, Montana State University (November 14, 1961)

Kenneth V. Bakke
David **L. Browman**
Denny D. Culbertson
Barry **P.** Davis
Harlan D. **Dulmage**
Jan C. Gerbase
Richard **J.** Konesky
Edmund **R. Kopitzke**
James D. **Mildenberger**
Robert L. Svehla
Elliot A. Welsh
William E. **Whitelaw**

MONTANA BETA, Montana State College (May 14, 1962)

Mir Kursheed Ali
Bernice **J.** Benson
John Bircher
David Booth
Roswitha **Bullinga**
Brace Furness
Gene Leslie Gallagher
Maurine Hager
Subodhehen die Mehta
Hartvig Melbye
Kjell Nielson
Celia Smith
David Stabio
Charles **Tolliver**
Robert Eugene Tracy

NEBRASKA ALPHA, University of Nebraska (May 6, 1962)

Jeanne A. Baird
Fredric L. Bauman
Dwain E. Blum
Jerre E. Bradt
Larry G. Bryant
Edward L. Calvin
Hugh S. **Carroll**
Marvin E. Criswell
James A. Davis
Patty A. **Edmiston**
Stanley B. **Eliason**
Loren **E.** Fairbanks
Anthony E. Hoffman
Alan C. Hurd
James E. **Huwaldt**
Kenneth W. Kaufman
William G. Kaufman
Stephen G. Kellison
Patrick H. Kelly
Jin Bai Kim
Gary D. Klussman
Thomas **O.** Kotouc
Robert **J. Kvall**
Phillip **M.** Leopold
James W. Lindsay
Roger **J. Mattson**
Robert C. **Miley,** Jr.
John I. **Molinder**
Merna M. Prettyman
Enid L. Reeder
Ronald L. Rogowski
Roger H. Schwabauer
Mark L. Teply
James **R.** Wall
Khosrow Hady Youssef

NEVADA ALPHA, University of Nevada (April 4, 1962)

Stanley E. Bush
Gail M. Chadwell
Robert V. Garcia
Charles E. **Gervie**
Michael C. **Hislop**
Robert D. Horn
James **M.** Hoyt
Reginald **Meaker**
Kathleen I. Miller
Ann L. **Rafetto**
Jeanne **M. Sadler**
Gary **M.** Tachoires
Alan S. Thomas
Calvin E. Thompson
James D. **Whitlock**
Charles W. **Wilmore,** Jr.

NEW HAMPSHIRE ALPHA, University of **New Hampshire** (May 24, 1962)

William A. Cooney
Ronald E. Cote
Judith A. Flagg
John A. Hinchey
William E. Lunt
Christine **M.** Malkowski
Robert **J.** Moore
Elizabeth A. Nichols
John L. **Olesniewicz**
Tmng Ngde **Quy**
Janet **P.** Ray
Charles **M.** Sawyer
Marilyn **J.** Staples

NEW JERSEY BETA, Douglas College **(May** 14. 1962)

Marie L. **Crawford**
Mary Ann **Ferrarese**
Anne L. **Grandin**
Elizabeth **M.** Grieder
Marianne Haulenbeck
Susan R. Kolba
Judith A. **Moraller**
Nancy F. Peters
Linda E. Peterson
Elaine R. Scheines

NEW MEXICO ALPHA, New Mexico State University (May **14,** 1962)

Ralph W. Ball
Richard K. Fergin
Hugh R. Gardner
Conrad G. Keyes
Maurice **Lipton**
Alfred R. Mitchell
Roger W. Mitchell
George P. **Mulholland**
Charles R. Parsons
Peter **J. Ruch**
Harold G. Rutherford, **II**
Hal L. Wallace
Benjamin Ward, Jr.

NEW YORK ALPHA, Syracuse University (April **24,** 1962)

Lee T. Bryant
Anthony P. **Carpentier**
John **J.** Doyle, Jr.
James E. **Dunn**
Linda **M. Dykeman**
Jack T. Ferguson
Lois Fero
Marcia G. Jackson
David F. Johnson
David **J.** Kahn
Alan Kaplan
Carolyn R. Kurgan
Vicki **Newman**
Jon B. **Pangborn**
Barbara **O.** Rauch
Richard Reed
Gary F. Rose
Linda **E. Serednicky**
James P. Walsh
Adrian A. **Warntz**
Leonora A. **Zobkiw**

NEW YORK BETA, Hunter College (April-4, 1962)

George S. **Alland**
Ahuva Barnett
Sally A. Burgeson
Susan **M.** Dotz
Lenore L. Feigelson
Ilene **J.** Goldstein
Harriet E. Hayes
Susan A. Kahn
Helene S. Lessinger
Philomena Russo
Susan B. **Sommerfeld**
Albert J. Webel
Pauline **Winkelman**

NEW YORK GAMMA, Brooklyn College (May 21, 1962)

Harvey **Braverman**
Michael **Brozinsky**
Bernard **Dickman**
Kenneth **Klein**
William Messing
Larry Padwa
Charles Rose
Edward Ross
Jack **Shapiro**

NEW YORK DELTA, New York University (February 13, 1962)

Edward H. Bersoff
Michael P. Swirnoff
John T. Wadsworth

NEW YORK EPSILON, St. Lawrence University (March 14, 1962)

John Victor Bauer
Lucretia Anne **Cognetta**

NEW YORK ETA, University of Buffalo (March 14, 1962)

Judith S. Ackerman
Arthur P. **Altman**
David V. **Bateman**
Robert J. Buck
Ralph L. Disney
Call F. Evans
Mary E. Graves
Marilyn A. Kanczak
Michael D. Kerwan
Anthony T. Lauria
Gordon L. **Liles**
Penelope A. Miller
William E. Price
John **Rogozinski**
Karl J. Schmeder
Ellen **R.** Schwartz
Irene L. **Sharpe**
Marilynn A. Tober

NEW YORK IOTA, Polytechnic Institute of Brooklyn (June 12, 1962)

Paul Feder
Stewart Nagler
Anthony J. Naro

NEW YORK KAPPA, Rensselaer Polytechnic Institute (February 11, 1962)

Alan W. Adler
Phil J. Best
Stephen H. Davis
Irwin Hirsch
Frederick A. Lehrer
S. Richard Mateosian
Ralph E. Morganstern
Ralph B. Prescott
William P. Rogers

NEW YORK KAPPA, Rensselaer Polytechnic Institute (June 1, 1962)

George Svetlichny
Michael John Arcidiacono
Lawrence Elliott Levine
Robert Frank Anastasi
Howard Butt Kushner

NEW YORK LAMBDA, Manhattan College (Spring, 1962)

Kevin C. Anderson
Joseph L. Bertorelli
Jack Bova
Joseph P. Genovese
Whitney S. Harris
John R. Mager
Bernard J. McCabe
Ronald R. Ragonese
Raymond F. Scanga
Gerald S. Silva
John Stout
Thomas G. Walsh

NEW YORK MU, Yeshiva College (May 1, 1962)

Elliot Beller
Martin Braun
Robert Feinennan
Joel Grossman
Steven E. Grossman
David Jacobson
Ben M. Schreiber
Lawrence Schulman
Bert Sirote
Benjamin Volk

NORTH CAROLINA ALPHA; Duke University (Spring, 1962)

Kenneth G. Brown
Joan S. Dimpfl
Jan M. Hollis
Edwin E. Messikomer
Hugh H. Mills, Jr.

NORTH CAROLINA BETA, University of North Carolina (November 20, 1961)

Anne E. Britton
Peter J. Brown
Judith E. Bush
Bobby F. Caviness
Thomas G. Eason
Charles E. Grigsby
Richard D. Hofler
Robert J. Hursey, Jr.
Knox H. Jones
Elizabeth A. McLeod
Martha A. Myers
Oscar R. Ogg
Sue F. Ross
Charles W. Shearin
Jance C. Shearin
John N. Tunstall
James R. J. Wadkins

NORTH CAROLINA BETA, University of North Carolina (February 26, 1962)

Robert Linn Bernhardt, III
Phillip Morris Kannan

NORTH CAROLINA GAMMA, North Carolina State University (April 26, 1962)

Robert R. Allran
Anne L. Fakler
Henry L. Fisher, Jr.
John D. Fulton
Claude D. Greeson
Thomas C. Harris
James L. Klingennan
Bobby E. Phillips
Gary D. Richardson
Robert T. Rood
Ralph E. Showalter
David C. Shreve
Jason L. Sox
William J. Tanner

OHIO ALPHA, Ohio State University (May 25. 1962)

Robert D. Baer
James K. Brooks
Stephen D. Comer
Ralph T. Compton, Jr.
David L. Deever
St. M. Noel Dreska
Dorothy S. GUY
James T. Hanlon
William H. Hosken
Kenneth R. Kimble
Gary G. Koch
Frederick S. Koehl
James Teh-zen Koo
Harry G. Miller
Charles E. Ryan, Jr.
Thurston W. Shook
Allan D. Silver
Alan L. Tyree
Jacob M. Weinberg
Thomas C. Wesselkamper

OHIO BETA, Ohio Wesleyan University (March 21, 1962)

Linda B. Connolly
Frederick M. Haney
Wilfred James Hansen
Donald S. Hetzel
Eric S. Johnson
John D. Kessler
Betsy L. Rittenhouse
Stanley D. Shawhan

OHIO ETA, Fenn College (June 15, 1962)

James Bevevino
Ray Brezic
Richard Cerny
George Herron
Kenneth Kasper
Robert Kime
James Logan
Norman Moore
Robert Weisensed

OHIO ETA, Fenn College (July 25, 1962)

F. Norman Lutz
Joseph Petsche

OHIO GAMMA, University of Toledo (May 6, 1962)

Robert S. Brundage
Ellen C. Brunt
Peggy Loo
Dennis F. Marvin
Thomas J. Mazuchowski
Susan Nichols
Keith C. Richards
Carmen Vittoria
Stephen M. Weglian, Jr.
Carole A. Wright

OHIO DELTA, Miami University (May 1, 1962)

Kenneth R. Adams
Nancy W. Boswell
George E. Fredericks
Carol V. Medlar
Lois J. Snyder

OHIO EPSILON, Kent State University (April 11, 1962)

Joyce L. Burrell
James H. Buxton
Douglas A. Cope
Dianne E. Coyne
Clifford H. Curtis
Donald A. Furey
Robert L. Furey
Barbara A. Grills
Susan K. Hill
Donald L. Hunston
Sandra L. Jackson
Neil M. Kettlewell
Carl D. Lytle
Glenice A. Nocjar
Mary J. Orovany
Kenneth A. Pew
Barbara L. Pletcher
Robert Schappelle
Richard G. Schooley
Donald B. Siano
James R. Weaber
Richard M. Williams
Lois I. Wilson

OHIO ZETA, University of Dayton (Spring, 1962)

Michael Barnoski
Joseph P. Brzozowski
Thomas S. Clifford, S.M.
Max G. Gruendel
Darrell J. Horwath
Laurens W. Houttuin
James A. Kass
John Edward Kauflin
Joseph D. Kolesar
Frank T. Kozuh, S.M.
Marcella A. Sakalas
Thomas E. Scheper, S.M.
Charles D. Schweickart
Alan G. Stevens
James D. VanHausen

OHIO ETA, Fenn College (February 23, 1962)

John E. Conroy
Jack E. Crow
David Herlacher
Wayne Hudson
Bruce Johansen
C. Robert Klotz
Frank Lozier
Henry A. Putre
Kenneth Schwartzkopf
David Sealey
John J. Whitely
Edgar D. Young

OKLAHOMA ALPHA, University of Oklahoma (February 13. 1962)

John R. Lesem
Charles E. Maudlin, Jr.
Monte D. Miller
Helen M Murphy
Gerald L. Smith
Robert W. Vaughen

OKLAHOMA ALPHA, University of Oklahoma (May 4, 1962)

Lynne F. Capehart
Charles H. Cook
Stephen DeCanio
Gary F. Esch
Forrest R. Miller, Jr.
Leo J. Pratte
G. Joseph Wimbish, Jr.

OKLAHOMA BETA, Oklahoma State University (January 4, 1962)

A. Paul Brokaw
David R. Bryan
E. Ann Campbell
Sue Coates
Ralph Ferguson
Darrell Gimlin
Joseph S. Greene, Sr.
Ann Hemker
Parshall L. Howe
Jerry Johnson
Mary Johnson
Jimmie G. Lakin
James C. Loggins
Lyman L. McDonald
Billy G. Monks
Karen Owen
John R. Perkins
Linda L. Priest
Robert Sasaki
Margaret Sauls
Rose Stuntz

OKLAHOMA BETA, Oklahoma State University (April 19, 1962)

Anthony R. Abernethy
George W. Brewer
Jerry W. Brown
Norman Bryant
George M. Butler
Burton K. Chambers
Clifford C. Chrisman
Boyd A. Christensen, Jr.
Fred E. Collings
Brace C. Edgar
Ronald Gardner
Vadis G. Godbey
Glenn Hightower
William Ralph Lee
Terral L. McKellips
George W. Miller
Nancy Page
Chin-loh Pan
Barton S. Perrinne, Jr.
Willa E. Pickering
George F. Reese
Jack B. Reid
Song-yeong Ruo
Many A. Smith
Wayne R. Stoddard
Homer H. Tang

OREGON ALPHA, University of Oregon (May 29, 1962)

Roger Backen
Virginia Emilie Brooke
Donald Leroy Bmwn
David Welland Chapman
Jean Therese Collins
Gary Lee Corliss
Mary Katherine Davidson
Kathleen Donaldson
John Edlund
Barbara Louise Elerath
Robert Charles Ghent
Sharlyn Lee Gillis
Peggy Lee Huston
Jimmy Hinkhouse
Paul William Janus
Robert Carl Juola
Karen Kreuder Hoff
Douglas Kelker
Susan Jean Krutsch
David Leeming
Patricia Jo McCorkle
James Wells McCoy
Allen McDaniels
Gary Hunter Newton
Phyllis Nicholson
Patricia Novak
Leroy Peterson
Roger Price
Darrell Ray Quarles
Karl Reitz
Chaika Kim Rhee
Pamela Robinson
Stewart Sawyer
Robert Siegenthaler
Harry Dean Smith
Delbert Wayne Snyder
Carol Jean Somekawa
Larry Virgin
John Williams

OREGON BETA, Oregon State University (May 22, 1962)

Robert J. Albright
Janet E. Allison
James J. Auborn
Rodney Allan Badger
Gerald L. Belt
Jo Ann Berryman
Robert Russel Beutler
Leslie H. Birdsall
Chester O. Bishop, Jr.
John Amos Boles
Jimmie H. Boone
Gary L. Brown
Manuelita A. Brown
William G. Brown
Thomas Danforth Burnett
Gilbert Wayne Butler
Don L. Campbell
Theodore W. Cannon
Jerry Joel Congdon
Charles J. Conlee
Larry R. Cooper
Elizabeth Louis Simpson Curl
William W. Curtis
Bernard E. Davis
Arthur F. Deardorff
Jack D. Dennon
Sandra D. Dunagan
Stuart Ames Eide
John Alan Evans
John E. Ferguson, Jr.
Lloyd A. Fraser
Raymond F. Fry
William Earl Gilbert
David E. Gooding
George Joseph Grammens
Phillip M. Gregg
Jerry R. Grunwald
Keith R. Hacker
John A. Hocken, Jr.
James H. Husband
Ronald E. Johnson
Kenneth Boyd Knechtel
Sid G. Knox
Lawrence John Koth
David H. Y. Lin
Sharon H. S. Long
Michael H. Malmros
Kaye Kent Manchester
Michael Franklin McCoy
Robert W. McCoy
James Lee McElroy
Roger L. McNair
Penelope K. Miller
John L. Morack
David R. Moser
Mahmoud Abd-elfattah Moustafa
Thomas Munkres
Junior A. Nagaki
Mark I. Nelsen
George Papageorge
Bill Papakonstantinou
David Harrison Paup
Dean Edward Perry
John W. Powell, Jr.
Merwyn C. Powell
Arthur Douglas Ritchie
William John Robertson
Eugene R. Royer
Michael B. Schartz
Sandra Schlinkman
Richard G. Schluter
Arnold Leon Schmeder, Jr.
William R. Scofield
George Edward Seymore
Robin H. Shaylor
Richard E. Siemens
Gerald Silke
Keith B. Snyder
Raj Pal Soni
J. R. Spoerl
Robert Lee Steele
Frederick J. Sterk
Donald P. Stockard
Alan R. Stoebig
Micael J. Stomp
James Akiyoshi Sunamoto
Patricia Sweet
Michael T. Swotakowski
Michael Allen Talvola
Alice A. Thompson
Jay R. Turner
Sommai Vongsure
James D. Wagner
Darryl William Walker
John P. Ward
Michael S. Waterman
Ronald N. Webb
Floyd R. Wendlberger
Jane M Whitcomb
Jean M. Wick
John L. Wilkerson
Frank O. Williams
James B. Wuori
James W. York

PENNSYLVANIA ALPHA, University of Pennsylvania (Spring, 1962)

Robert Averell
Elliott M Badder
Melanie Costa
Paul Cotton
Jay E. Israel
Elliott D. Kieff
Eugene H. Poppel
Betty Rarig
Bruce Schoenberg
Michael Tinkleman

PENNSYLVANIA GAMMA, Lehigh University (November 9, 1961)

Thomas E. Bachman
James A. Begley
R. Barry Bischoff
Philip H. Brandt
Charles A. Falcone
Leo B. Freeman, Jr.
Robert J. Galgon
Ronald J. Hartranft
G. Raymond Hodil, Jr.
Charles W. Hofer
John P. Janowski
Gary K. Kohler
Donald Lookingbill
Thomas G. Ludwig
Michael J. Mendelsohn
Frank R. Moore
Bernard E. Musch, Jr.
J. Calvin Nafziger
Walter H. Nichols
Norman L. Owsley
John R. Pivnichny
Thomas A. Reilly
Thomas A. Slivinski
Philip H. Swain
John K. Wagner
R. Dennis Wayson
John R. Webb

PENNSYLVANIA ZETA, Temple University (March 26. 1962)

Mary Becket
Sue Berwind
Arthur-Bobrove
Sheldon Eisenberg
Anne Glass
Joseph Mandelbaum
Marlene Rosenzweig
Arnold Rubin
Herb Silverman
Robert Stout
Joseph Yeager

PENNSYLVANIA DELTA, Pennsylvania State University (May 15. 1962)

Richard A. Alo
Mary E. Angstadt
James B. Bartoo
William S. Bickel
Dorothy M. Blankeslee
David L. Briggs
John J. Broderick
Aviva R. Brown
Joan B. Byers
Judith Q. Chouinard
Richard L. Clark
Edward E. Collins
James L. Cooley
John C. Davis
John W. Diercks
Lynne E. Eisenstaedt
Douglas H. Frank
Anthony J. Felice, Jr.
Walter L. Ghering
Carole L. Gibson
Charlotte R. Gilson
Barry S. Goluboff
John A. Gustavson
Beverly A. Heckman
Charles E. Houck
William M Houck
Robert L. Hunt
Leland T. Mahood
Donald J. McMahon
George E. Mitchell
Robert C. Moore
Linda Moritz
Stanislaw Mrowka
Edgar P. Niner
Robert W. Oliver
Carole L. Pryor
Linda L. Rife
Frederick C. Schwerer
Maria C. Shopay
Norma Shusterman
Jane M. Silverstein
Vincent W. Slivinsky
Michael J. Smith
Rodney L. Smith
Edward J. Unger
Michael Varano
William E. Wilson

RHODE ISLAND ALPHA, University of Rhode Island (April 26, 1962)

Harry A. Bender
Richard Bender
Albert A. Bennett
Joel Cohen
Mary H. Cummins
Stephen DeMetrick
Diana Drew
James Foster
Carl A. Garabebian
Jerald H. Greenberg
John T. James, Jr.
Clifford D. Leitao
Domenick Lombard!
Mersina Moskos
Edward M. Pease
Nancy E. Randall
Maureen Russo
Robert J. Salhany
Jacob R. Stauffer
William Strawderman
E. Ramnath Suryanarayan
Ronald A. Tourgee

SOUTH CAROLINA ALPHA, University of South Carolina (May 1, 1962)

Robert F. Bradley
John G. Breland, Jr.
Sheang P. Chan
Carolyn P. Crawley
Peggy A. Crawley
Rodney F. Epting
Dianne Fredy
George T. Hawkins
David B. Heape
Thomas E. Hogarth
Carolyn Honeycurt
Barbara Loewe
Susan Loewe
Roy Lucas, Jr.
Edwina Rudisill
Ann Sanders
Wei-Mei Shyu
Pelham Thomas
W. Joseph Van Dyke
James Wallace
Lindley H. Webb
Ronald A. Young

SOUTH CAROLINA ALPHA, University of South Carolina (August, 1962)

Nathan E. Hardwick
Marshall Pace
Edward C. Thomas

SOUTH DAKOTA ALPHA, University of South Dakota (May 2, 1962)

Elwood D. Baas
William D. Carda
Cleland V. Cook
Ervin M. Eltze
Charles I. Ernst
James C. Fargo
Eugene M. Frohling
Allison J. Haeder
Joy Hamrin
Shapleigh W. Howell
Eugene S. Jacobs
Helmut B. Nunn
Harley M. Oien
Joyce E. Palmer
John E. Powell
Roger F. Reinking
Arthur L. Robertson
Jacqueline M. Rose
David E. Rumelhart
George D. Schmieg
Byron K. Schulke
James W. Shouse
Robert H. Sieling
John D. Snyder

TEXAS ALPHA, Texas Christian University (Spring, 1962)

Braynard R. Traweek

VIRGINIA BETA, Virginia Polytechnic Institute (May 15. 1962)

Jean M. Carr
James F. Chew
Bryant Chow
Dan Chun
Bennie A. Clemmer
Selwyn L. Flournoy
John R. Hanson
Margaret A. Hockensmith
Merrill W. Hume
Michael H. Kutner
Jack M Mendel
William C. Nelson
James E. Norman, Jr.
Agnes C. Taylor
Donald G. Thomas
John E. Tindall
Theodore C. M. Tung
Catherine L. Wilson
Janet Yates

WASHINGTON BETA, University of Washington (March 8, 1962)

Brandt R. Allen
Naydene Chadson
Gordon P. Chinn
Peter W. Cornue
Donald E. Ekman
M. Owen Englehart
William L. Ferris
Victor Hasselblad
Thomas D. Hayward
James P. Jones
Robert G. Krause
Elizabeth M. Kutter
Karen M. Lenzie
George F. Mason
Jean M. Murakami
Emiko J. Nakamura
Richard A. Owens
Robert T. Ramsay
Richard C. Reinhold
James A. Skrivan
Nancy J. Strother
Joe Tomita
Ronald L. VanEnkevort

WASHINGTON BETA, University of Washington (May 22. 1962)

Dave Barnette
John L. Bergaren
John R. Cherevnik
Janet Crist
John Engstrom
Victor I. Francisco
Louise B. Haack
Pamela Johnson
Duane Alfred King
Larry E. Knop
Frank Kukla
Ronald Lim
John Lippert
Diana Lubash
Gary Miller
Paul Mitts
John Reeves
Jack Sanford
Judith Sleight
Douglas Smith
Donald Sloppier
Kuang-Tao Tang
Neil W. Zimmerman

WASHINGTON GAMMA, Seattle University (Spring. 1962)

John E. Meany
Michael D. Moran
David L. Predeek
Leon M. Puzon
Alva M. Wright

WISCONSIN ALPHA, Marquette University (April 7. 1962)

Kenneth J. Bukowski
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