THE PENTAGON

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CONTENTS

NATIONAL OFFICERS

Kappa Mu Epsilon, mathematics honor society, was founded in 1931. The object of the society is fivefold: to further the interests of mathematics in those schools which place their primary emphasis on the undergraduate program; to help the undergraduate realize the important role that mathematics has played in the development of western civilization; to develop an appreciation of the power and beauty possessed by mathematics; due, mainly, to its demands for logical and rigorous modes of thought; to provide a society for the recognition of outstanding achievement in the study of mathematics at the undergraduate level; to disseminate the knowledge of mathematics and to familiarize the members with the advances being made in mathematics. The official journal, THE PENTAGON, is designed to assist in achieving these objectives as well as to aid in establishing fraternal ties between the chapters.

GRAPH COLORING

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Suppose there are six committees that are scheduled to meet once a week each. The problem is to make a schedule for these meetings in such a way that if two committees have one or more common members they will meet at different times. In other words, the members belonging to more than one committee will be able to attend each of their meetings.

One way to approach this problem might simply be by trial and error -- that is, designing a schedule and making several changes until an appropriate schedule is constructed. However, an easier and more efficient method might be by composing a graph with the given information.

First, the data is put into a table. Refer to Figure 1.1. The committees are numbered 1-6. The x's represent committees that have a common member. The -'s

represent committees that have no common members.

	1	2	3	4	5	6
1	-	-	-	-	-	x
2	-	-	x	-	x	-
3	-	x	-	x	x	x
4	-	-	x	-	-	x
5	-	x	x	-	-	x
6	x	-	x	x	x	-

Figure 1.1

This information can be transferred into a graph in which each committee is represented by a point. If two committees have a common member, their corresponding points are connected by a line. Figure 2.1 illustrates this.

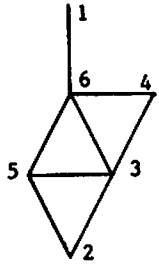

Figure 2.1

Each of the vertices in the graph are committees which need to be assigned regular meeting times. Instead of assigning meeting times, colors can be assigned to each vertex in such a way that if two vertices are joined by a line, they must be a different color. This is called graph coloring. If such an assignment can be carried out using at most n colors, then it is called an n-coloring and is n-colorable. The smallest number n such that the graph is n-colorable is called the chromatic number of the graph.

A planar graph is a graph containing no two edges that cross except at the vertices. Figure 3.1 shows a non-planar graph. Notice, that though a graph may have edges that cross besides at the vertices, it is not necessarily non-planar. There may be another way to draw the graph without edges that cross, (except at the vertices). Figure 3.2 and 3.3 illustrate this.

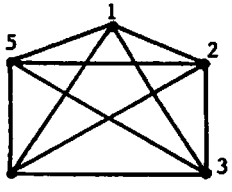

Figure 3.1

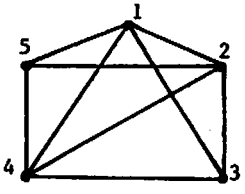

Figure 3.2

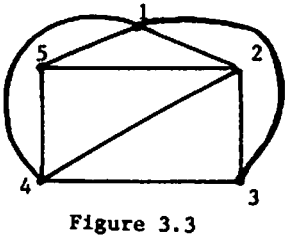

Figure 3.3

A map has never been found for which more than four colors are needed. This presents the Four-Color Problem. The Four-Color Problem is the problem of proving that every possible planar map can be colored in not more than four distinct colors so that no two regions of the same color have a common boundary.

Theorem 1: Every planar map is four-colorable.

The Four-Color Conjecture is over 100 years old. its earliest trace is in a letter to Sir Rowan Hamilton in Dublin from the London mathematician Augustus DeMorgan on the 23rd of October, 1852. DeMorgan said that he had a student who asked about a figure divided into regions differently colored so that no two regions with a common border were the same color. He suggested that four colors may be wanted, but no more. The student was Frederick Guthrie, later a physicist, who said he heard the problem from his brother, Francis Guthrie, later a mathematician, who had guessed it in connection with a coloring of a map of England.

In the beginning, the problem wasn't taken too seriously. Mathematicians considered it to be fairly self evident. Over the years a number of incorrect

proofs have appeared. Some of the world's most competent mathematicians have attempted to solve the Four-Color Problem, but have done so unsuccessfully. Finally in 1976, the Four-Color Problem was solved with proof, by Kenneth Appel and Wolfgang Haken. The correctness of the proof cannot be checked without the aid of a computer.

The study of the Four-Color Conjecture for over a century was not done in vain. Many useful ideas and theorems on graph coloring came about by it.

Return to the first example -- the problem of constructing a schedule of meeting times for six committees. By assigning each vertex in Figure 2.1 a color so that two vertices connected by a line receive a different color, an assignment of meeting times can likewise be made. First, one vertex is selected at random, and a color is assigned to it. Then, the same color is assigned to another vertex not connected to the first. Likewise, a third vertex not connected to the first or second is assigned the same color. This process is continued until all the vertices possible are colored with that same color so that no two vertices colored are connected by an edge. Now a second color is

selected and the procedure is repeated. The entire process is continued until each vertex in the graph is assigned a color. This is illustrated in Figures 4.1, 4.2, and 4.3.

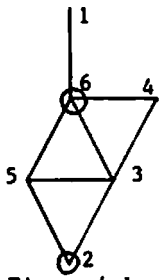

Figure 4.1

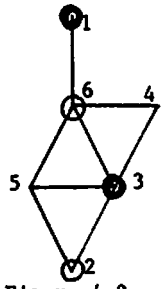

Figure 4.2

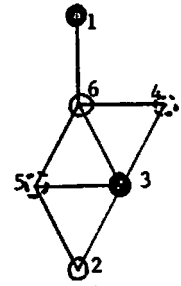

Figure 4.3

The final graph in figure 4.3 can be colored with 3 colors. Thus it is 3-colorable and its chromatic number is 3. From this, it is determined that at least three meeting times are needed in order to accomodate members belonging to more than one committee.

Another theorem involving graph coloring is stated in Theorem 2.

Theorem 2:

> Any map on a plane can be colored with two colors if all its vertices are even -- that

is, at each vertex, an even number of lines meet.

First, maps that can be formed by straight lines will be considered. The ordinary checkerboard is a familiar example. A less regular pattern is shown in Figure 5.1. It is easily shown that two colors are sufficient for all such maps. If another straight line is added to the map (the heavy black line in Figure 5.1) to any properly colored straight line map, the map will be divided into two separate maps, each colored appropriately when considered separately, but with pairs of the same colored regions along the straight line.

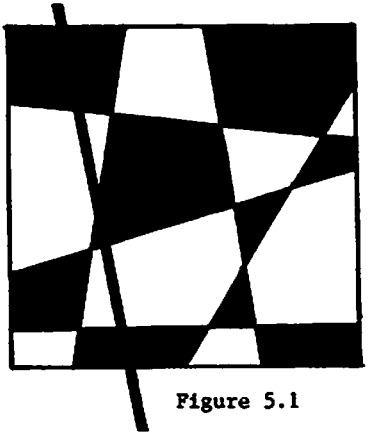

Figure 5.1

To restore a proper coloration to the map as a whole, all that must be done is to exchange the colors on one side of the line. This is shown in Figure 5.2. This new map is now properly colored.

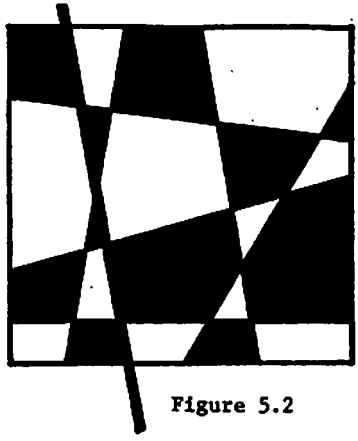

Figure 5.2

An informal proof of Theorem 2 might be as follows. Refer to Figure 6.1, 6.2, and 6.3.

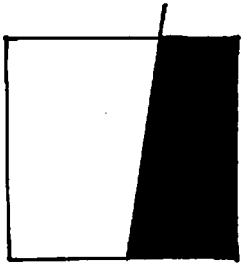

Figure 6.1

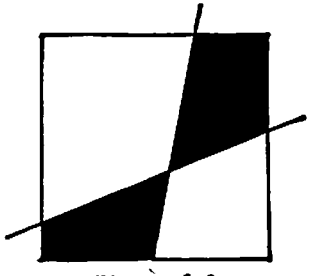

Figure 6.2

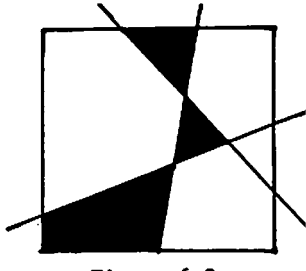

Figure 6.3

(1) Divide a plane into two regions with a single line. Obviously, it can be colored with two colors.

(2) Draw a second line and reverse the colors on one side.

(3) Continue this process with any number of lines.

Theorem 3 can be generalized to cover less rigid maps such as the map in Figure 7.1. This is drawn with endless lines that either cut across the entire map or lie on it as simple closed curves. If a line is added, the colors are reversed on one side, as before. If a closed curve is added, the colors are reversed either inside the curve or outside it.

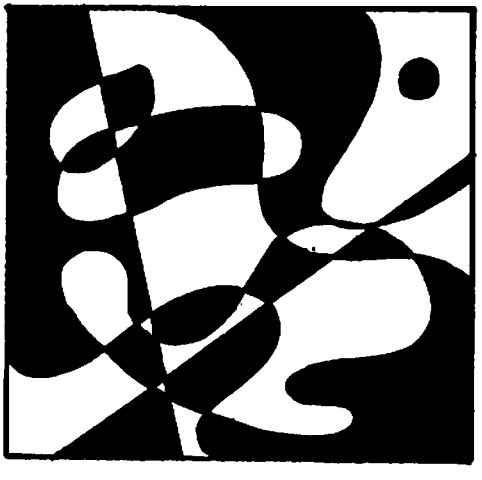

Figure 7.1

The discussion in this paper has been very brief in comparison to the vast amount of information and theorems related to graph coloring. As one can see though, this topic can be used in a number of applications. Thus graph coloring is practical, and the study of it can be very significant.

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THE CHINESE REMAINDER THEOREM

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INTRODUCTION

The Chinese Remainder Theorem, which is a very useful tool in Number Theory and Algebra, is called this because the problems it was used to solve are found in ancient Chinese literature. In the following, the history of the theorem will be followed from the first century A.D. to the present day. We will then state the theorem and give some examples, including an interesting application. Before seeing the applications, we first trace the theorem back to the First Century A.D. when Sun-tse discovered the Chinese Remainder Theorem.

ORIGIN OF THE CHINESE REMAINDER THEOREM

The Chinese Remainder Theorem was first given in the form of a rule called t'ai-yen (great generalization), by Sun-tse in a Chinese work Suan-ching (arithmetic) about the First Century A.D. "He used this rule to determine a number having the remainders 2, 3, and 2 when divided by 3, 5, and 7 respectively. He determined the auxiliary numbers 70, 21, and 15 multiples of 5·7, 3·7, and 3·5 and having the remainder 1 when divided by 3, 5, and 7 respectively. The sum 2·70 + 3·21 + 2·15 = 233 is one answer. Casting out a multiple of 3·5·7 we obtain the least answer 23" [5., p. 57].

Sun-tse's rule became known in Europe because of the article, "Jottings on the Science of Chinese Arithmetic," written by Alexander Wylie. During the next 700 years, several men challenged the validity of the rule and others gave rules that were clearer.

In 717 A.D., Yih-hing, in his book t'ai-yen-lei-schu, gave a generalization in the case

where the moduli (divisors) m_i are not relatively prime. "He expressed the least common multiple of $m_1, m_2, \ldots, m_k$ as a product $m = u_1u_2,,,u_k$ of relatively prime factors, including unity, such that u_i divides m_i. Then if $_1 \equiv 0 \pmod{m/u_i}$ and $_i \equiv 1 \pmod{u_i}$, where $(i = 1,\ldots,k)$, hence $x = {}_1r_1 + {}_2r_2 + \ldots$ is a solution" [5., p.60], where r_i are the remainders. Over the next several centuries, this rule was applied to a variety of problems.

In the Fifteenth Century, a general rule corresponding to the Chinese t'ai-yen rule was proven. This rule was applied and discussed by Euler, Gauss, Lagrange, and others.

Finally in 1906, G. Arnoux stated the Chinese Remainder Theorem as we know it today: "If $m_1,\ldots,m_n$ are relatively prime in pairs, $M = m_1 \cdot m_2 \cdot \ldots \cdot m_n$, $u_i = M/m_i$ and if $a_1,\ldots,a_m$ are integers such that $a_iu_i \equiv r \pmod{m_i}$ for $i = 1,\ldots,n$, then $a_1u_1 + \ldots + a_nu_n \equiv r \pmod{M}$" [5., p.65]. In the following sections it will become clear how this theorem can be beneficial.

STATEMENT OF THEOREM

The Chinese Remainder Theorem is a fairly simple theorem to follow and understand. We restate it in a slightly different form.

The Chinese Remander Theorem

"Suppose $m_1, m_2, \ldots, m_n$ are pairwise relatively prime, that is, $(m_i, m_j) = 1$ if $i \neq j$. Let $M = m_1 m_2 \ldots m_n$. Then define numbers $b_1, b_2, \ldots, b_n$ by choosing $y = b_j$ as a solution of

$$y\frac{M}{m_j} \equiv 1 \pmod{m_j}, \text{ where } (j = 1,2,\ldots,n).$$

The general solution of systems

$$x \equiv a_1 \pmod{m_1}$$

$$x \equiv a_2 \pmod{m_2}$$

$$\ldots$$

$$x \equiv a_n \pmod{m_n} \text{ is}$$

$$x \equiv a_1 b_1 \frac{M}{m_1} + a_2 b_2 \frac{M}{m_2} + \ldots + a_n b_n \frac{M}{m_n} \pmod{M}$$" [8., p. 48].

The proof of this theorem can be found in many texts on Number Theory and Algebraic Structures.

EXAMPLES OF HOW TO USE THE CHINESE REMAINDER THEOREM

Our first problem will be to solve the following two systems of congruences:

$$\text{I}: \begin{cases} x \equiv 1 \pmod 2 \\ x \equiv 2 \pmod 3 \\ x \equiv 3 \pmod 5 \end{cases} \qquad \text{II}: \begin{cases} x \equiv 1 \pmod 3 \\ x \equiv 3 \pmod 5 \\ x \equiv 5 \pmod 7 \end{cases}$$

Solving system I, we find M, m_1, m_2, and m_3: $M = 2 \cdot 3 \cdot 5 = 30$, $m_1 = 2$, $m_2 = 3$, $m_3 = 5$. We also see that m_1, m_2, and m_3 are pairwise relatively prime. Since $y = b_1$ is a solution of $15y \equiv 1 \pmod 2$, we choose $b_1 = 1$. Similarly $y = b_2$ is a solution of $10y \equiv 1 \pmod 3$, so $b_2 = 1$ and finally $y = b_3$ is a solution of $6y \equiv 1 \pmod 5$, so $b_3 = 1$. Then $b_1\frac{M}{m_1} = 1 \cdot 15 = 15$, $b_2\frac{M}{m_2} = 1 \cdot 10 = 10$, and $b_3\frac{M}{m_3} = 1 \cdot 6 = 6$. We obtain $x \equiv 1 \cdot 15 + 2 \cdot 10 + 3 \cdot 6 \equiv 15 + 20 + 18 \equiv 53 \pmod{30}$, or $x \equiv 23 \pmod{30}$.

Now, we should have no trouble in solving system II. We find that $M = 3 \cdot 5 \cdot 7 = 105$, $m_1 = 3, m_2 = 5$, and $m_3 = 7$. We then solve the congruences $35y \equiv 1 \pmod 3$ find $b_1 = -1$, $21y \equiv 1 \pmod 5$ finding $b_2 = 1$, and $15y \equiv 1 \pmod 7$ finding $b_3 = 1$. Then $b_1\frac{M}{m_1} = -1 \cdot 35$, $b_2\frac{M}{m_2} = 1 \cdot 21 = 21$,

$b_3\frac{M}{m_3} = 1\ 15 = 15$. So the solution of system II is $x \equiv$

$-35\ 1 + 3\ 21 + 5\ 15 \quad -35 + 63 + 75 \equiv 103 \pmod{105}$.

Our last example, before we move on to an application, is finding integers that have certain remainders, such as the original Chinese puzzles.

Our problem is to find all integers that have remainders 1 or 2 when divided by each of 3, 4, and 5. In other words, we want to find common solutions of the system of congruences.

$$x \equiv 1 \text{ or } 2 \pmod 3,$$

$$x \equiv 1 \text{ or } 2 \pmod 4, \text{ and}$$

$$x \equiv 1 \text{ or } 2 \pmod 5.$$

We have $m_1 = 3$, $m_2 = 4$, and $m_3 = 5$, so $M = 60$. Solving like the previous examples, we solve $20y \equiv 1 \pmod 3$ obtaining $b_1 \equiv -1$, $15y \equiv 1 \pmod 4$ obtaining $b_2 = -1$, and $12y \equiv 1 \pmod 5$ obtaining $b_3 = -2$. Then $b_1\frac{M}{m_1} \equiv -1\ 20 \equiv -20$, $b_2\frac{M}{m_2} = -1.15 = -15$, and $b_3\frac{M}{m_3} = -2\ 12 = -24$. If we insert the values of 1 and 2 into the equation $x \equiv -20a_1 - 15a_2 - 24a_3 \pmod{60}$, we obtain the following table:

a_1	a_2	a_3	$x \pmod{60}$
1	1	1	$-20 - 15 - 24 \equiv -59 \equiv 1$
1	1	2	$-20 - 15 - 48 \equiv -83 \equiv 37$
1	2	1	$-20 - 30 - 24 \equiv -74 \equiv 46$
1	2	2	$-20 - 30 - 48 \equiv -98 \equiv 22$
2	1	1	$-40 - 15 - 24 \equiv -79 \equiv 41$
2	2	1	$-40 - 30 - 24 \equiv -94 \equiv 26$
2	1	2	$-40 - 15 - 48 \equiv -103 \equiv 17$
2	2	2	$-40 - 30 - 48 \equiv -118 \equiv 2$

Therefore, the integers having remainders 1 or 2 when divided by 3, 4, and 5 are given by $x \equiv 1, 2, 17, 22, 26, 37, 41, 46 \pmod{60}$.

AN APPLICATION OF THE CHINESE REMAINDER THEOREM

We now apply the Chinese Remainder Theorem to an interesting word problems. The problem is:

> If eggs are taken from a basket two, three, four, five, and six at a time there are left over, one, two, three, four, and five eggs respectively. If they are taken out seven at a time, there are no eggs left over. How many eggs are in the basket?

We begin by setting up the system of congruences that will enable us to apply the Chinese Remainder Theorem. The system is: $x \equiv 1 \pmod 2$, $x \equiv 2 \pmod 3$, $x \equiv 3 \pmod 4$, $x \equiv 4 \pmod 5$, $x \equiv 5 \pmod 6$, and $x \equiv 0 \pmod 7$. Since 2,3,4,5,6, and 7 are not relatively prime in pairs, we must solve this system by dividing it into three different systems of congruences.

The first system is: $x \equiv 1 \pmod 2$, $x \equiv 2 \pmod 3$, $x \equiv 4 \pmod 5$, and $x \equiv 0 \pmod 7$. We know that $M = 210$. We solve $105y \equiv 1 \pmod 2$ obtaining $b_1 = 1$, $70y \equiv 1 \pmod 3$ obtaining $b_2 = 1$, $42y \equiv 1 \pmod 5$ obtaining $b_3 = -2$, and $30y \equiv 1 \pmod 7$ obtaining $b_4 = -3$.

Now since $b_1\frac{M}{m_1} = 1 \cdot 105 = 105$, $b_2\frac{M}{m_2} = 1 \cdot 70 = 70$, $b_3\frac{M}{m_3} = -2 \cdot 42 = -84$, and $b_4\frac{M}{m_4} = -3 \cdot 30 = -90$, have $x \equiv 1 \cdot 105 + 2 \cdot 70 - 84.4 - 90 \cdot 0 \equiv 245 - 336 \equiv -91 \equiv 119 \pmod{210}$.

The second system of congruences is: $x \equiv 2 \pmod 3$, $x \equiv 3 \pmod 4$, $x \equiv 4 \pmod 5$, and $x \equiv 0 \pmod 7$. We know that $M = 420$. We solve $105y \equiv 1 \pmod 4$ obtaining $b_1 = 1$, $140y \equiv 1 \pmod 3$ obtaining $b_2 = -1$, $84y \equiv 1 \pmod 5$ obtaining $b_3 = -1$, and $60y \equiv 1 \pmod 7$ obtaining $b_4 = 2$.

Now, since $b_1\frac{M}{m_1} = 1 \cdot 105 = 105$, $b_2\frac{M}{m_2} = -1 \cdot 140$, $b_3\frac{M}{m_3} = -1 \cdot .84 = -84$, and $b_4\frac{M}{m_4} = 2 \cdot 60 = 120$, we have $x \equiv 3 \cdot 105 - 140 \cdot 2 - 84 \cdot 4 + 0 \cdot 120 \equiv 3115 - 280 - 336 \equiv -301 \equiv 119 \pmod{420}$.

The third system is: $x \equiv 4 \pmod 5$, $x \equiv 5 \pmod 6$, and $x \equiv 0 \pmod 7$. We know that $M = 210$, we solve $42y \equiv 1 \pmod 5$ obtaining $b_1 = -2$, $35y \equiv 1 \pmod 6$ obtaining $b_2 = -1$, and $30y \equiv 1 \pmod 7$ obtaining $b_3 = -3$.

Since $b_1\frac{M}{m_1} = -2 \cdot 42 = -84$, $b_2\frac{M}{m_2} = -1 \cdot 35 = -35$, and $b_3\frac{M}{m_3} = -3 \cdot 30 = -90$, we have $x \equiv -84 \cdot 4 - 35 \cdot 5 - 90 \cdot 0 \equiv -511 \pmod{210} \equiv 119 \pmod{210}$.

We now know that $x \equiv 119 \pmod{420}$. Let's check it: $119 \equiv 1 \pmod 2$, $119 \equiv 2 \pmod 3$, $119 \equiv 3 \pmod 4$, $119 \equiv 4 \pmod 5$, $119 \equiv 5 \pmod 6$, and $119 \equiv 0 \pmod 7$. So 119 satisfies all the congruences. But it is not the only answer. How many eggs are in the basket? There are 119, 539, 959, ...

CONCLUSION

The Chinese Remainder Theorem has been stated and illustrated in this paper. Discovered in the First Century A.D., this theorem has been developed and revised over the years however, the basic concept still remains. The Chinese Remainder Theorem "determines the existence and number of solutions of a set of n linear congruences in n moduli and one unknown" [3., p.52]. As has been illustrated, the Chinese Remainder Theorem can be a very helpful tool in solving many word problems, as well as, other difficult and puzzling questions. Much

has been learned from Sun-tse and his rule and therefore, the Chinese Remainder Theorem should be considered a major stepping stone in the field of mathematics.

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THE PROBLEM CORNER

EDITED BY KENNETH M. WILKE

The Problem Corner invites questions of interest to undergraduate students. As a rule the solution should not demand any tools beyond calculus. Although new problems are preferred, old ones of particular interest or charm are welcome, provided the source is given. Solutions should accompany problems submitted for publication. Solutions of the following problems should be submitted on separate sheets before 15 July 1986. Solutions received after the publication deadline will be considered also until the time when copy is prepared for publication. The solutions will be published in the Fall, 1987 issue of THE PENTAGON, with credit being given to student solutions. Affirmation of student status and school should be included with solutions. Address all communications to Kenneth M. Wilke, Department of Marthematics 275 Morgan Hall, Washburn University, Topeka, Kansas 66621.

PROPOSED PROBLEMS

Problem 397: Proposed by the editor.

Which of the following expressions is larger $\sqrt{10} + \sqrt{29}$ or $\sqrt{73}$. Verify your answer without using any table, calculator or computer.

Problem 398: Proposed by the editor.

Fred noticed two different triangular scraps of wood on the floor beside his saw. He didn't think anything about them until his son noticed that each of them has sides which are an integral number of inches. Then he noticed that for each piece the area is 3/4 of the perimeter. What are the dimensions of each triangle and are there any others which have the same ratio between the area and the perimeter?

Problem 399: Proposed by Bill Olk, University of Wisconsin-Madison, Madison, Wisconsin.

Find all right triangles whose sides are integers and whose inscribed circles have prime radii.

Problem 400: Proposed by the editor.

Fred was calculating the area of the ellipse $144x^2 + 256y^2 = 36864$ when his friend Al commented that he could produce a closed curve which had exactly the same perimeter as Fred's ellipse and enclosed an area of exactly 16 more square units. Show how this can be done without performing any calculations.

Problem 401: Proposed by Bill Olk, University of Wisconsin-Madison, Madison, Wisconsin.

Show that if $b^2 < 3ac$ for real numbers a, b and c, then the equation $x^3 + ax^2 + bx + c = 0$ has one real root and two complex roots.

Problem 385: Proposed by the editor.

A preschool nursery class has three girls. The boys have not yet been counted. An hour later a new child is brought into the nursery. Then a child is selected at random to be photographed. If the child who was selected to be photographed is a girl, what is the probability the last addition to the nursery class was a boy?

Solution by the editor.

Let b denote the number of boys originally in the class. Then at the time of the photograph, the respective numbers of boys and girls is either (b,g) = (b,4) or (b + 1,3) depending upon whether the last addition to the class was a girl or a boy.

Let GP denote the event of photographing a girl and BA denote the arrival of a boy. Then P(BA) · P(GP given BA) = P(BA and GP) = P(GP) · P(BA given GP). Now P(BA) = 1/2 , P(GP given BA) = 3/(b + 4) and P(GP) = 7/(2b + 8). Substituting these values in the preceding equation, we find P(BA given GP) = 3/7 .

Problem 387: Proposed by Charles W. Trigg, San Diego, California.

Two n-digit primes are said to be complementary if their sum is 10^n. Show that with the single exception of 3, 7 both primes must be of the form 6k-1.

Solution by Bob Prielipp, University of Wisconsin-Oshkosh, Oshkosh, Wisconsin.

We shall show the following stronger result: If p and q are prime numbers, both different from 3, whose sum is 10^n for some positive integer n, then both p and q are both of the form 6k-1.

Since p and q are primes whose sum is 10^n for some positive integer n, both p and q must be odd primes. Every odd prime different from 3 is either of the form 6k+1 or 6k-1. By considering choices of sign independently, we have four possibilities for p and q:

$$p \equiv \pm 1 \pmod 6 \quad \text{and} \quad q \equiv \pm 1 \pmod 6.$$

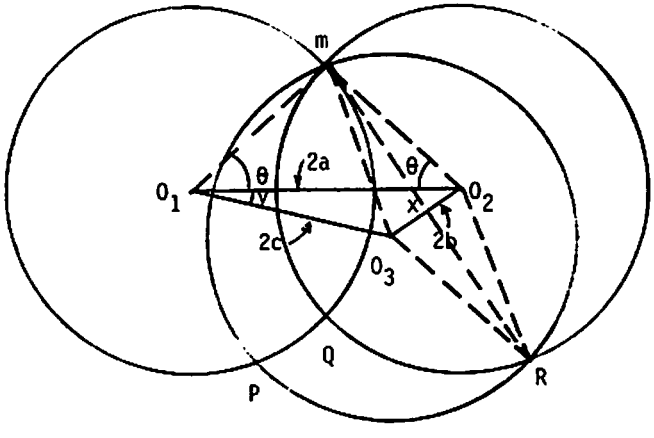
Since $10^n \equiv 4 \pmod 6$ for each positive integer n and since $p + q = 10^n$, we must have $p \equiv q \equiv -1 \pmod 6$ thereby establishing the desired result.

Also solved by the proposer.

Editor's Comment: The featured solution includes a necessary side condition which was omitted in the proposer's statement of the problem. In addition, each of the primes 97 and 997 may be substituted for 7 in the posed problem as extra exceptions. This becomes necessary when the two primes are 3 and $10^n - 3$.

Problem 388: Proposed by the Dmitry P. Mavlo, Moscow, U.S.S.R.

Three circles of equal radii r with respective centers O_1, O_2, and O_3 have the common point M as shown in the figure below. Denote by P the point of intersection of circles O_1 and O_3, by Q the intersection of the circles O_1 and O_2 and by R the point of intersection of the circles O_2 and O_3. Denote by $S_{O_1O_2O_3}$ the area of the triangle $O_1O_2O_3$ and by S_{PQR} the area of the "curved triangle" PQR. Prove that $S_{PQR} = 2\, S_{O_1O_2O_3}$.



Solution by Oscar Castenada, San Antonio, Texas.

Let the sides of triangle $O_1O_2O_3$ be 2a, 2b and 2c as shown in the figure. Denote the area of triangle $O_1O_2O_3$ by $[O_1O_2O_3]$. But since each of the triangles MO_1O_3, MO_2O_3 and MO_1O_2 is isosceles, we have

$$[O_1O_2O_3] = [MO_1O_3] + [MO_2O_3] - [MO_1O_2] =$$

$$c\sqrt{r^2 - c^2} + b\sqrt{r^2 - b^2} - a\sqrt{r^2 - a^2} . \qquad (1)$$

Denote angles MO_1O_2, $O_2O_1O_3$ and $O_1O_2O_3$ by Θ, Y and X respectively. Then angles MO_3O_1 and MO_3O_2 equal $\Theta + Y$ and $\Theta + X$ respectively. Hence from triangle $O_1O_2O_3$ we have

$$X + Y + \Theta = 90 . \qquad (2)$$

Denote the area of the intersection of the circles O_2 and O_3 by (2,3). Note that MO_2RO_3 is a rhombus.

Then (2,3) = area of sector O_2RM + area of sector O3RM - the area of rhombus MO_2RO_3 $= \pi r^2 (4(\Theta + X)/360) - 2b(RM)$

$$= \pi r^2 (\Theta + X)/90 - 2b\sqrt{r^2 - b^2} . \qquad (3)$$

Similarly, $(1,3) = \pi r^2 (\Theta + Y)/90 - 2c\sqrt{r^2 - c^2}$. (4)

Also, $(1,2) = \pi r^2 (\Theta)/90 - 2a\sqrt{r^2 - a^2}$. (5)

Then from (1), (3), (4) and (5) we have

$$S_{PQR} = \pi r^2 - (2,3) - (1,3) + (1,2) = \pi r^2 -$$

$$\pi r^2(\Theta + X + Y)/90 + 2b\sqrt{r^2 - b^2} + 2c\sqrt{r^2 - c^2} - 2a\sqrt{r^2 - a^2}$$

$$= 2[O_1O_2O3] = 2S_{O_1O_2O_3} .$$

Also solved by E. Averbuch, USSR and the proposer.

Problem 389: Proposed jointly by Ambati Jaya Krishna, Johns Hopkins University, and Mrs Gomathi S. Rao, Orangeburg, New Jersey.

$$\text{Let } M = 1 + \frac{1}{3} + \frac{2!}{3\cdot 5} + \frac{3!}{3\cdot 5\cdot 7} + \ldots \quad .$$

Does the following sum converge?

$$\sum_{n=1}^{\tan M} (-1)^{n+1} \sum_{s=0}^{n} \sum_{i=0}^{s} (-1)^{s-1} \; {}_nC_s \; {}_sP_i \quad .$$

Solution by the proposers.

First we evaluate M. In the interval $-1 < x < 1$,

$$\text{Sin}^{-1}x/\sqrt{1 - x^2} = x + (2/3)x^3 + (2\cdot 4/3\cdot 5)x^5 + (2\cdot 4\cdot 6/3\cdot 5\cdot 7)x^7 + \ldots$$

$$= x(1 + (1/3)2x^2 + (2!/3\cdot 5)2^2x^4 + (3!/3\cdot 5\cdot 7)2^3x^6 + \ldots) \quad (1).$$

Setting $x = 1/\sqrt{2}$ and simplifying, we get $M = \pi/2$.

$$\text{Let } S_n = \sum_{s=0}^{n} \sum_{i=0}^{s} (-1)^{s-i} \; {}_nC_s \; {}_sP_i \; . \text{ Thus}$$

$$S_n = n! \sum_{s=0}^{n} \sum_{i=0}^{s} (-1)^{s-i} \; {}_{n-i}C_{s-i}/(n-i)!$$

$$= n! \sum_{i=0}^{n} (1/(n-i)!) \sum_{s-i}^{n} (-1)^{s-i} \; {}_{n-i}C_{s-i}$$

$$= n! \sum_{i=0}^{n} (1/(n-i)!) \sum_{j=0}^{n=i} (-1)^{j} \; {}_{n-i}C_{j} \; .$$

Since the inner sum in the last expression represents $(1 - 1)^{n-i}$ or 1 according to whether $i = n$ or $i = n$, it follows that $S_n = n!$. Thus the problem can be restated as

$Dn = \sum_{n=1}^{\infty} (-1)^{n+1} \, n!$. Now consider the integral

$\int_{1}^{\infty} e^{-t}/t \; dt$ which is convergent. Setting $y = 1/t$,

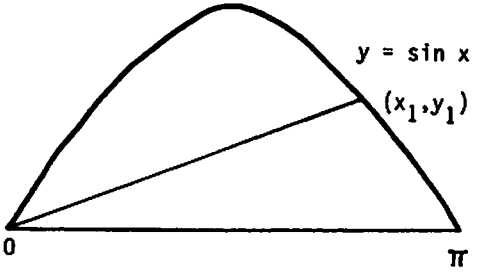
this integral becomes $\int_{0}^{1} (e^{-1/y})/y \; dy$ which, according to [1]

has the value $(1/e)/1! - 2! + 3! - 4! + \ldots)$. Thus the given sum converges. The sum is 0.59633... .

[1] Lacroix, Calculus Diff. et Int., Paris, 1819, Vol.3, p.517.

Problem 390: Proposed by Fred A. Miller, Elkins, West Virginia.

Bisect the area under one arch of the curve $y = \sin x$ by drawing a line from the origin to the curve.



Solution by the proposer.

By integration the area under the sine curve is 2. Let x_1 and y_1 denote the coordinates of the point of intersection of the desired line and the curve $y = \sin x$. The equation of the line is given by

$$y/x = (y_1/x_1) . \qquad (1)$$

Then

$$1 = \int_0^{x_1} (\sin x - y_1 x/x_1)dx = - \cos x - (y_1 x^2)/x_1 \Big|_0^{x_1} .$$

Then since $y_1 = \sin x_1$, we have

$$2 \cot x_1 + x_1 = 0.$$

By iteration or otherwise $x_1 = 2.458714$ radians.

Problem 391: Proposed by the editor.

Let r be a real number such that r^{1835} and r^{1986} are both integers. Prove that r is an integer also.

Joint solution by Bob Prielipp and Pat Collier, University of Wisconsin-Oshkosh, Oshkosh, Wisconsin.

From the Euclidean Algorithm we find that

$$1835 \cdot 605 + 1986 \cdot (-559) = 1.$$

Thus $r = (r^{1835})^{605} (r^{1986})^{-559} = (r^{1835})^{605} / (r^{1986})^{559}$. But r^{1835} and r^{1986} are both integers so integral powers of these numbers are integers also. Hence r is a rational number; i.e. $r = a/b$ for some integers a and b where a and b are relatively prime and b is positive. Because a and b are relatively prime, a^{1835} and b^{1835} are also. But $r^{1835} = a^{1835} / b^{1835}$ is an integer. But this occurs only if $b = 1$. thus r is an integer.

Late solutions were received from Jack T. Miller, LaSalle University, Philadelphia, Pennsylvania for problem 374 and from Thomas J. LeCompte, Illinois Theta Chapter, Naperville, Illinois for problem 380.

THE CURSOR

EDITED BY JIM CALHOUN

THE CURSOR was chosen as the name of this section of THE PENTAGON because of the role that mathematics plays in pointing the way toward the understanding of important concepts of computer science.

Like most applied sciences, computer science depends heavily upon a large body of mathematical theory, and it is our goal that the ideas presented in this department explore relationships between these two disciplines. Readers are encouraged to submit articles directed toward this goal. Address all correspondence to Jim Calhoun, Computer Science Department, Western Illinois University, Macomb, IL. 61455.

PERFORMANCE ANALYSIS OF COMPUTER SYSTEMS

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*Dennis Mok is assistant professor of computer science at Western Illinois University. His research interests are computer simulation and analytical analysis of computer systems and networks. He received his Ph.D. in Industrial Engineering from Iowa State University.

Performance of computer systems is analysed typically because one wants to know if the system can perform up to one's expectation; what are the limits; and how the system compares with other similar systems. There are three different approaches one can go about in analyzing computer performance. One can either:

- physically install the whole computer system and actually measure its performance. Or,
- simulate system operations using computer simulation techniques to predict computer performance. Or,
- construct analytical models to estimate computer performance.

Among the various approaches, it is the analytical approach that is of most interest, and perhaps most intellectually challenging, to mathematicians. If properly implemented, the analytical approach is the least expensive and most efficient method in generating performance results. This paper discusses some of the fundamental concepts used in the mathematical analysis of computer systems.

There are three types of computer systems: an open system, a closed system, and a combined open-closed system. Open systems usually process submitted jobs in batches (see Fig. 1). Jobs in an open system can be in one of three states:

1. Input state- where jobs are queued for execution by the

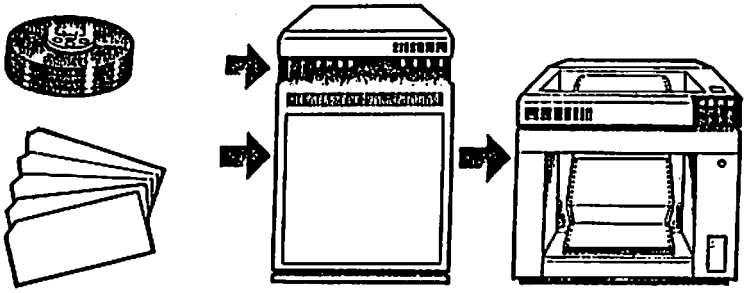

Figure 1. An Open System

central processor.

2. Execution state- where jobs are executed.

3. Output state- where jobs are queued for output by the printer.

Jobs in a closed system are usually interactive query-response oriented (see Fig. 2). Other than the input and execution states

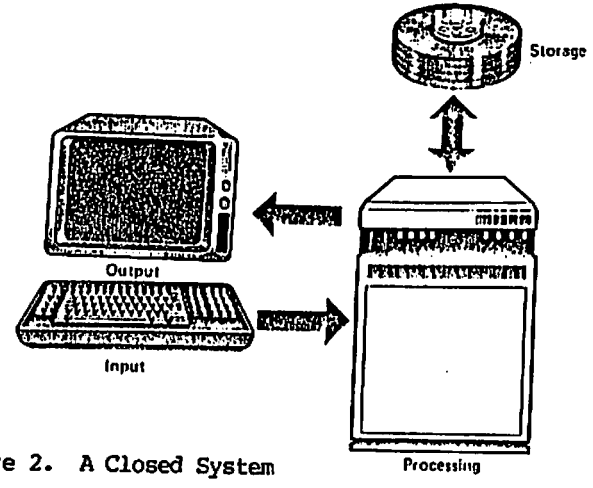

Figure 2. A Closed System

described above for the open system, jobs in a closed system are in the so called thinking state after being executed by the central processor. This state includes time a user spends on going through results of the previous execution, plus elapsed time one spends in thinking and typing in the next query or job. The major differences between the open and the closed systems are that jobs in an open system are assumed to be from an infinite population; whereas for a closed system the number of jobs in the system is limited by the maximum number of terminals connected to the central processor. Also, in an open system the job input rate is independent of the job execution rate of the central processor; whereas for a closed system the job input rate is a function of the service rate of the central processor (this is true because users in a closed system have to wait for a response before they can submit another query). Therefore the analysis of a closed system is mathematically more complicated than that of an open system (which can usually be analysed by simple queueing models).

A combined open-closed system is a computer system having the characteristics and features of both the open and the closed systems (see Fig. 3).. This is the type of system most commonly installed to service a large number of users with different computational needs (a mix of relatively few time consuming batch oriented jobs and a large number of interactive query-response oriented jobs). Analysis of this type of system requires one to

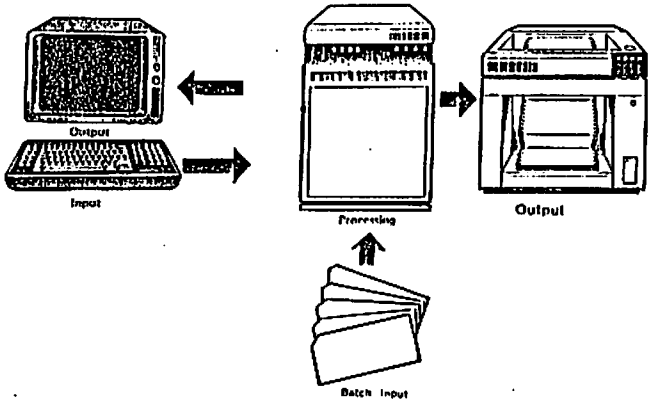

Figure 3. A Combined Open-Closed System

clearly define the interactions between the open and the closed parts of the system. Typically, job inputs from the terminals are queued in a higher priority queue than batch jobs (this is done to maintain a high throughput for interactive users). Also, results of interactive jobs are occasionally output to the printer (see Fig. 4).

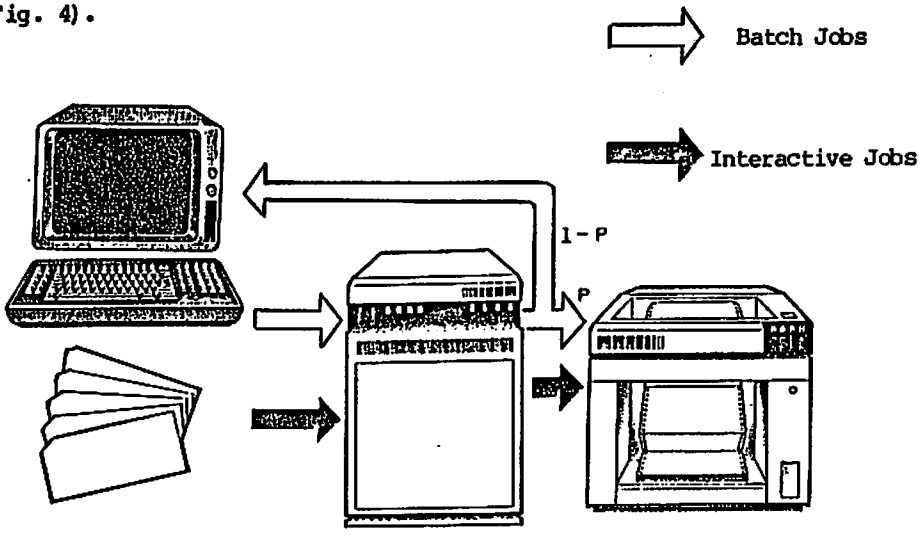

Figure 4. Message Flow of Interactive and Batch Jobs in a Combined Open-Closed System

41 Performance of the three types of computer systems just described can be analysed using queueing theory. Queueing theory involves the mathematical study of queues or waiting lines. It provides a large number of alternative analytical models for describing a waiting-line situation. Mathematical results predicting some of the characteristics of the waiting line often are generated by these models. Detailed discussion of queueing theory and its applications can be found by reading L. Kleinrock's excellent monographs [1] and [2].

The operating characteristics of computer systems are largely determined by two statistical properties, namely, the probability distribution of job (interactive or batch) interarrival times and the probability distribution of job execution (service) times. For real computer systems, these distributions can take on almost any form. However, to formulate a queueing-theory model as a representation of the real system it is necessary to specify the assumed form of each of these distributions. For computer systems, job inputs are generally bursty and random in nature. Their execution times are usually short with a few jobs requiring relatively long service times. Therefore, in order to maintain analytical tractability, and at the same time selecting a probability distribution that is sufficiently realistic, the exponential distribution is often assumed for job interarrival and service times.

An open system can be modeled as shown in Fig. 5. The average job arrival rates to the card reader, central processor, and printer queues are all the same (here we have a cascaded three-stage system, with the output of one stage acting as input to the next stage) and are denoted by λ. The service rates of the three machines are μ_1, μ_2, and μ_3 respectively. Using the derived queueing-theory formulas of a Single Line-Single Server queue, the probability that exactly n jobs are in queue i, is

$$P_{n,i} = (1 - \frac{\lambda}{\mu_i})(\frac{\lambda}{\mu_i})^n \qquad \text{, for } i = 1, 2, \text{ and } 3.$$

The expected queue length for each machine is,

$$L_i = \frac{\lambda^2}{\mu_i(\mu_i - \lambda)}$$

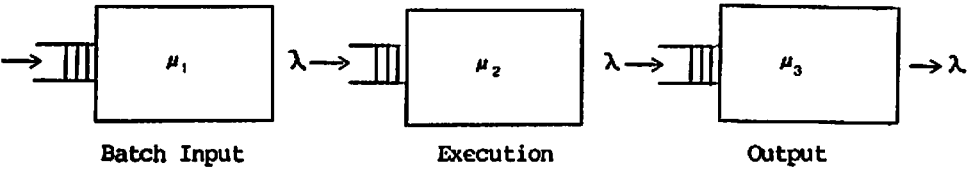

Figure 5. Queueing Model of an Open System

The expected delay (queueing and service) of a job in the system, is

$$D = \sum_{i=1}^{3} \frac{1}{\mu_i - \lambda}$$

A closed system can be modeled as shown in Fig. 6. All users are assumed to have the same average job processing rate μ_u. With N terminals in the system (finite input source), the aggregated average job arrival rate to the central processor is $N\lambda$. The probability that exactly n jobs are in the central processor queue, is

$$P_n = \left(\frac{N!}{(N-n)!}\left(\frac{N\lambda}{\mu_c}\right)^n\right) \Big/ \sum_{n=0}^{N}\left(\frac{N!}{(N-n)!}\left(\frac{N\lambda}{\mu_c}\right)^n\right)$$

where μ_c is the average service rate of the central processor. The expected queue length, is

$$L = \sum_{n=1}^{N} (n-1)P_n$$

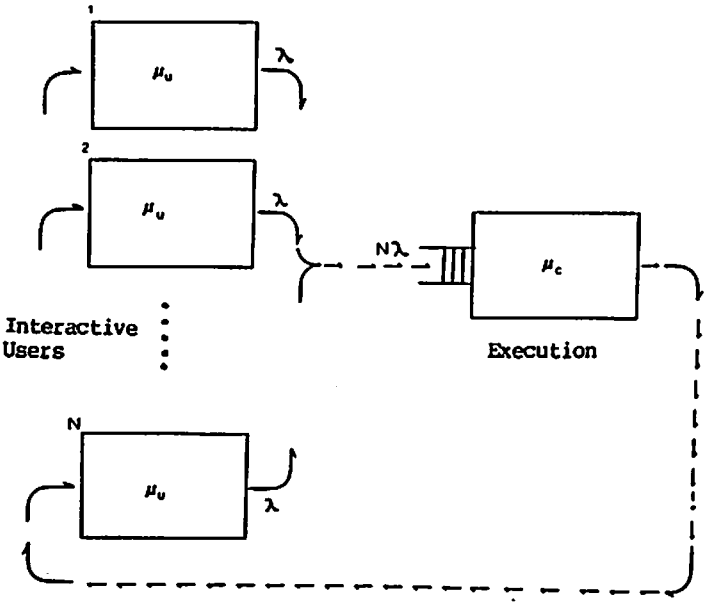

Figure 6. Queueing Model of a Closed System

The expected delay in the system, is

$$D = \frac{L}{N\lambda} + \frac{1}{\mu_C} + \frac{1}{\mu_U}$$

The average user query rate, is

$$\lambda = 1/D$$

which, unlike that of an open system queueing model, is a function of N, μ_C, and μ_U.

A combined open-closed system can be modeled as shown in Fig. 7. Analysis of this system is similar to those described for the open and the closed systems. The only exceptions are in calculating the average job arrival rate to the printer queue and the queueing formulas for interactive and batch jobs at the two central processor queues. The average job input rate to the printer

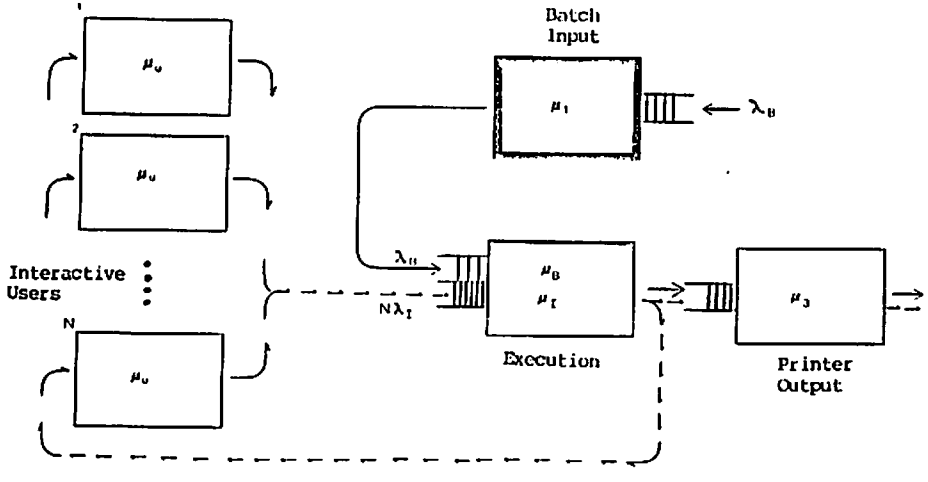

Figure 7. Queueing Model of a Combined Open-Closed System

queue, is

$$\lambda_P = P\, N \lambda_I + \lambda_B$$

where P is the probability that the result of an interactive job is also routed to the printer.

Job input to the central processor is represented by a priority-discipline queueing model. This model assumes that there are two priority classes (interactive jobs have higher priority than batch jobs). Service to batch jobs is nonpreemptive; i.e., jobs being served can not be ejected back into the queue if a higher priority job enters the queueing system. Mean service time is not the same for the two priority classes. Interactive jobs have mean service rate μ_I, and batch jobs have mean service rate μ_B. Under the assumption of infinite population for both sources (which we use to approximate a finite priority source with large number of terminals), it has been determined by Jaiswal [3] that the average queue lengths are:

$$L_I = \frac{N\lambda_I}{N\lambda_I+\lambda_B}\left(\frac{N\lambda_I}{\mu_I}+\frac{\lambda_B}{\mu_B}\right)+\frac{(N\lambda_I)^2(N\lambda_I E(S_I^2)+\lambda_B E(S_B^2))}{2(N\lambda_I+\lambda_B)(1-N\lambda_I/\mu_I)}$$

and

$$L_B = \frac{\lambda_B}{N\lambda_I+\lambda_B}\left(\frac{N\lambda_I}{\mu_I}+\frac{\lambda_B}{\mu_B}\right)+\frac{1}{2}\lambda_B\left(N\lambda_I E(S_I^2)+\lambda_B E(S_B^2)\right)$$
$$\left(\frac{\lambda_B(1+\mu_B/\mu_I)+\frac{N\lambda_I}{\mu_I}\left(1-\frac{N\lambda_I}{\mu_I}-\frac{\lambda_B}{\mu_B}\right)}{\left(1-\frac{N\lambda_I}{\mu_I}-\frac{\lambda_B}{\mu_B}\right)\left(1-\frac{N\lambda_I}{\mu_I}\right)}\right)$$

where $E(S_\chi^2)$ denotes the second moment of the service-time distribution (i.e., χ= I, or B).

For the two job classes the expected queueing delay is,

$$D_{q,I} = L_I/(N\lambda_I), \qquad D_{q,B} = L_B/(\lambda_B)$$

All the presented queueing formulas assume, for analytical tractability, buffers of infinite capacity. The distribution of queue length calculated using the formulas may be used to guide the designer in his choice of actual buffer size, one which will insure an acceptable level of buffer overflow. The queueing delay (waiting time) is a measure of the response of the system. It is the queueing theoretic analog of the familar impulse response of a linear system. All these are important parameters in the evaluation of computer system performance.

Our goal in this paper has been to demonstrate the fundamental concepts in the analysis of computer systems. The analytical models presented may be used to approximate real systems. If one is desirous of obtaining numerical results in selecting the precise design parameters for his/her system, then it is necessary to go to much more elaborate analytic models.

References

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2. Kleinrock, L., Queueing Systems, Vol. 2: Computer Applications, Wiley, New York, 1976.

3. Jaiswal, N., Priority Queues, Academic Press, New York, 1968.

KAPPA MU EPSILON NEWS

Edited by M. Michael Awad

News of chapter activities and other noteworthy KME events should be sent to Dr. M. Michael Awad, Historian, Kappa Mu Epsilon, Mathematics Department. Southwest Missouri State University, Springfield, Missouri 65804.

CHAPTER NEWS

Alabama Zeta, Birmingham-Southern College, Birmingham
Chapter President - Kathy Ray
54 actives

Mr. Wayne Stuenkel and Mr. John Kerper (one of our alumni) from the actuarial department at Protective Life Insurance Company presented our major spring program. They discussed requirements for becoming an actuary and employment prospects for this field. Other 1986-87 officers: Curtis Tucker, vice president; Tracy Mayfield, secretary; Charles Hartzog, treasurer; Lola F. Kiser, corresponding secretary; David Johnson, faculty sponsor.

California Gamma, California Polytechnic State University, San Luis Obispo
Chapter President - Jeanmarie Short
40 actives, 26 initiates

The chapter assisted the Mathematics Department with the annual Cal Poly Mathematics Contest which attracted over 500 high school students to the campus. Weekly meetings featured alumni and industry speakers. Erik Harder was the recipient of the Arthur Andersen & Co. Professional Performance Award. Joseph Beardsley and Jon Burt were joint recipients of the Founders Award. Jacquie O'Meara was the recipient of the KME Scholarship. Other 1986-87 officers: Anna Heimgartner, Jacquie O'Meara and Susan Ridenour, vice presidents; Stephanie Logan, secretary; Jon Fingold, treasurer; George R. Mach, corresponding secretary; Adelaide T. Harmon-Elliott, faculty sponsor.

Colorado Alpha, Colorado State University, Fort Collins
Chapter President - Robyn Thoelke
10 actives, 14 initiates

Other 1986-87 officers: Valerie Volfeldt, vice president; Tom Painter, secretary and treasurer; Arne Magnus, corresponding secretary.

Colorado Gamma, Fort Lewis College, Durango
Chapter President - Johnny Snyder
42 actives, 16 initiates

An initiation ceremony for 16 new members was held on Feb. 26. Following the ceremony, President Bernard Adams and Dean Ed Angus gave short talks and a reception was held. Chapter President Glen Hodges gave a talk on "Finite Difference Equations" at the March 25 meeting. Membership cards were distributed and pins ordered. Chapter member Alan Brown gave a talk on "Mathematical Magic Tricks" at the April 15 meeting. The new officers were elected and plans were made for the High School Mathematics Contest to be held on campus on May 2. Other 1986-87 officers: Amy Getz, vice president; Jennifer Mabry, secretary; Thomas Wyman, treasurer; Richard A. Gibbs, corresponding secretary and faculty sponsor.

Connecticut Beta, Eastern Connecticut State University, Willimantic
Chapter President - Jeffrey Solman

(1) Joint induction ceremonies with Opsilon Pi Epsilon (Computer Science Honor Society); 150 guests in attendance. (2) Three guest speakers (two of whom are graduated KME members). (3) Numerous trips to attend colloquia at nearby colleges. (4) Spring picnic at notorious off-campus student residence--no arrests! Other 1986-87 officers: Heidi Gantick, vice president; Rose Carchidi, secretary; Peter Wetherell, treasurer; Stephen Kenton, corresponding secretary and faculty sponsor.

Georgia Alpha, West Georgia College, Carrollton
Chapter President - Kristi Milam
22 actives, 15 initiates

Our annual spring initiation meeting was held on May 8. We initiated a record high number of 15 students. We then elected chapter officers for 1986-87. Afterwards we attended a reception honoring the 1986 pledges. At the reception it was announced that three KME members would receive academic scholarships for 1986-87: Tracy Tepp, Kristi Milam, and Shelby Frost. On May 14 all of the new pledges were recognized at the annual Honors Day Convocation. Other 1986-87 officers: Keisha Cantrell, vice president; Shelby Frost, secretary; Jonathan Card, treasurer; Joe Sharp, corresponding secretary and faculty sponsor.

Illinois Delta, College of St. Francis, Joliet
23 actives
12 initiates

Officers for 1986-87 will be elected in September, 1986. Sister Virginia McGee is the corresponding secretary and faculty sponsor.

Illinois Zeta, Rosary College, River Forest
Chapter President - James Blondin
12 actives
11 initiates

Former KME chapter president, Mark Siwek, discussed his work in the actuarial field at the initiation on January 21. Members Ginger Moores and Jim Blondin presented problems having to do with the Koenigsberg bridges and the calendar, respectively, at spring meetings. Members took part in a new tutoring program. Members also sold popcorn and hot dogs to raise money for next year's trip to the convention at San Luis Obispo, CA Gamma. Other 1986-87 officers: Gina Suareo, vice president; Rosa Soma, secretary; Linda Russo, treasurer; Sister Nona Mary Allard, corresponding secretary; Mordechai Goodman, faculty sponsor.

Illinois Eta, Western Illinois University, Macomb
Chapter President - Dave Hermann
20 actives, 8 initiates

Fundraisers included a chili luncheon and a pizza party. Theresa Szczurek was named Young Career Woman of the Year. The annual Spring Banquet and Spring Initiation Ceremony were held. Other 1986-87 officers: Chris Byer, vice president; Janet Kester, secretary and treasurer; Alan Bishop, corresponding secretary.

Illinois Theta, Illinois Benedictine College, Lisle
Chapter President - Meredith Jirka
15 actives

The chapter met each month during the spring semester. The primary activity was the 1986 Illinois Benedictine College Math Contest for high school students. Over 100 students from 20 high schools participated. Chapter members helped with hosting, distribution of materials, proctoring and scoring. Members also submitted problems and solutions for consideration as contest items. In May the chapter was responsible for making arrangements for the Mathematical Sciences Awards Ceremony. Dr. Karl Martersteck of AT&T was guest speaker. Our next initiation will be held during the fall, 1986, semester. Other 1986-87 officers: Jenny Rissky and Paul Toussaint, vice presidents; Diane Frieders, secretary; Diane Dipiertro, treasurer; James M. Meehan, corresponding secretary and faculty sponsor.

Indiana Alpha, Manchester College, North Manchester
Chapter President - Mark Cawood
25 actives, 6 initiates

We held our annual spring induction banquet in Warsaw, Indiana, where we inducted our six new members. In addition, we had a guest speaker from Chicago, Kurt Denlinger of Hewitt Associates, address the topic of Actuarial Sciences. At our banquet, we inducted our 1986-87 officers, and we wished our graduating students good luck with their careers. Other 1986-87 officers: Norman Rohrer, vice president; Lisa Jerva, Secretary; Dawn Crum, treasurer; Ralph B. McBride, corresponding secretary and faculty

sponsor.

Indiana Beta, Butler University, Indianapolis

Judi Morrell is the corresponding secretary. Other 1986-87 officers will be elected at a later date.

Iowa Alpha, University of Northern Iowa, Cedar Falls
Chapter President - Tracy Konrad
39 actives, 2 initiates

Scott Kibby, Tim Roegner, Tracy Konrad, and the faculty sponsor attended the KME Region IV convention at Drury College, completing the trip in forty hours, twenty of which were spent on the road. Students who presented papers at local KME meetings are: Tracy Konrad on "Variations of Buffon's Needle Problem," Tony Hays on "Computer Graphics for Classroom Use," and Ron Lower on "MuMath-MuSimp." The KME initiation banquet this spring had a record attendance of 37 members and guests. Following the initiation, David Bishop presented his paper on "Applications of Matrices to Optics." Other 1986-87 officers: Jeremy Phillips, vice president; Anthony Hays, secretary; David Bishop, treasurer; John S. Cross, corresponding secretary and faculty sponsor.

Iowa Delta, Wartburg College, Waverly
Chapter President - Catherine Peterson
25 actives, 32 initiates

The Iowa Delta Chapter of KME and the Department of Mathematics and Computer Science conducted the ninth annual Wartburg Math Field Day on March 15. A total of 103 students representing 15 schools participated. On March 22 the chapter initiated 32 new members, the largest group of new initiates in its 13 year history. Other 1986-87 officers: Alan Sexter, vice president; Susan Poppen, secretary; Tracy Ruhberg, treasurer; August Waltmann, corresponding secretary and faculty sponsor.

Kansas Alpha, Pittsburg State University, Pittsburg
Chapter President - Carla Pendleton
50 actives, 8 initiates

The Spring Semester began with a dinner and initiation for the February meeting. Eight new members were initiated at that time. After the initiation, Sharon Million gave a presentation on Halley's Comet in the PSU planetarium. Sue Pyles spoke at the March meeting. Her paper, "Calculation of the Backwater Curve for a Canal," was also accepted for presentation at the Region IV convention in Springfield, Mo. Five students and four faculty members attended this convention. The April meeting program was given by Roxanne Blessent, PSU biology student. She showed slides and described her research work with wild turkeys. The chapter assisted the Mathematics Department faculty in administering and grading tests given at the annual Math Relays, April 29, 1986. Several members also worked for the Alumni Association's annual Phon-o-thon. They received 4th prize for the amount of money raised by student organizations. The final meeting of the semester was a social event held at Professor McGrath's home. Homemade ice cream and cake were served to those attending. Officers for the 1986-87 school year were elected. The annual Robert M. Mendenhall awards for scholastic achievement were presented to Bryan Dawson and Cynthia Kellogg at the Mathematics Department Awards and Recognition Reception. They received KME pins in recognition of this honor. Other 1986-87 officers: Tom Skahan, vice president; Tammy Horn, secretary; Jennifer Munson, treasurer; Harold Thomas, corresponding secretary; Helen Kriegsman and Gary McGrath, faculty sponsors.

Kansas Gamma, Benedictine College, Atchison
Chapter President - Lisa Brox
27 actives, 9 initiates

Initiated into KS Gamma on 30 January were: Lisa Brox, Pat Hirsch, Jennifer LaFleur, Mark Leonard, John Liljestrand, Jeff Keithline, and Jim Wiggs. Dinner and a presentation on networking by faculty member Jim Ewbank preceded the initiation ceremony. Professor Judith Roitman from the University of Kansas spoke on "Questions Without Answers" at the 20 February meeting. Sophomores Lisa Brox and Pat Hirsch attended the March Regional Meeting in Springfield, MO, with faculty moderator Sister Jo Ann

Fellin. Many students helped with the chapter's 16th Mathematics Tournament for high school students. Jim Wiggs gave his soap bubble demonstration at the tournament and for a Discovery Day held earlier for prospective Benedictine students. Senior members received KS Gamma T-shirts as gifts at the picnic which closed the chapter activities for the year. Holding Sister Helen Sullivan Scholarship awards during the 1986-87 academic year will be senior Lisa Huerter and juniors Lisa Brox and Pat Hirsch. Sister Jo Ann Fellin, current faculty moderator and corresponding secretary for KS Gamma, will spend a 1986-87 sabbatical leave writing curriculum materials at the University of Notre Dame. Other 1986-87 officers: Pat Hirsch, vice president; Monica Halstead, secretary and treasurer; Richard Farrell, corresponding secretary; Tamara Lasseter, faculty sponsor; Carla Cihal, historian.

Kansas Delta, Washburn University, Topeka
Chapter President - Bryan Selby
18 actives, 6 initiates

Other 1986-87 officers: Joe Schisa, vice president; Torrey Head, secretary and treasurer; Robert H. Thompson, corresponding secretary; Ronald Wasserstein, faculty sponsor.

Kansas Epsilon, Fort Hays State University, Hays
21 actives, 13 initiates

The annual spring banquet was held on April 21, 1986. The chapter helped the department with plans for a Math Bowl competition among high school students from the area. Officers for 1986-87 have not yet been selected. Charles Votaw is the corresponding secretary. The faculty sponsor will also be determined later.

Kentucky Alpha, Eastern Kentucky University, Richmond
Chapter President - Theresa Terrell
24 actives, 24 initiates

Spring activities included general meetings, various fundraising activities, and an initiation of new members. Several

members gave talks at the EKU Symposium in the Mathematical Sciences. At some general meetings, students worked on mathematical puzzles and problems that came from recent journals. The speaker for initiation was Dr. Rodger Hammons who gave a fascinating talk entitled "Problem Solving with the Computer (and a Little Calculus)." Other 1986-87 officers: Tim Daniel, vice president; Pamela Adams, secretary; Karen Cardwell, treasurer; Patrick Costello, corresponding secretary; Bill Janeway, faculty sponsor.

Maryland Alpha, College of Notre Dame of Maryland, Baltimore
Chapter President - Donna Parker
8 actives, 6 initiates

On May 12, 1986, six new members were initiated at the annual dinner. Catherine Markey (one of the initiates) spoke on "Pixels and Turtles," a description of her independent study of computer graphics. Other 1986-87 officers: Angela Baccala, vice president; Mary Jo Maxa, secretary; Sister Marie Augustine Downing, corresponding secretary; Joseph DiRiezzi, faculty sponsor.

Maryland Beta, Western Maryland College, Westminster
Chapter President - Michele Lawyer
13 actives, 2 initiates

On March 13th, Maryland Beta held an induction dinner at the home of Dr. Lightner. Two new members were inducted. On March 14th, our chapter sponsored a Systems Programming Seminar. Four alumni, who are currently working in the field, returned to campus to inform us about the role of a systems programmer and how to get a job of this type in "the real world." During National Mathematics Awareness Week, April 14-18, our chapter promoted Mathematics on campus. On April 17th, we held a competition, open to everyone on campus, involving mathematical puzzles and brain-teasers. On April 26th, Nancy Sekira, president, Michele Lawyer and Dr. Lightner attended the Region I Convention at Frostburg State College. On May 3rd, we sponsored a Make-Your-Own-Button Booth at WMC's May Day to raise scholarship money. For our final event of the semester, the chapter sponsored a picnic for all Math Majors at the home of Michele Lawyer. Twenty-five majors and faculty members were in

attendance. Other 1986-87 officers: Chris Conklin, vice president; Elaine Joyce, secretary; Andy Raith, treasurer; James Lightner, corresponding secretary; Linda Eshleman, faculty sponsor.

Maryland Delta, Frostburg State College, Frostburg
Chapter President - Donna Pope
37 actives, 13 initiates

The Maryland Delta Chapter hosted the Region I Convention on April 25-26, 1986. The keynote address was given by Dr. James M. Landwehr, Supervisor, Data Analysis Group, Mathematical Sciences Center, AT&T Bell Laboratories. His presentation was entitled "Applications of Recent Ideas of Statistical Data Analysis in Industry." Student presentations included the following: Doris Cook, Susquehanna University, "Snowflakes, Flowsnakes, and Other Perplexing Figures;" Scott Inch, Bloomsburg University, "N-Dimensional Tic-Tac-Toe;" Richard Zimmerman, Frostburg State College, "Torus Geometry." Dr. Edward White, Frostburg State College, gave an invited faculty presentation, "1 = 2, It's True!?." Other 1986-87 officers: Bradley Richards, vice president; Kevin Lowery, treasurer; Donald Shriner, corresponding secretary; John Jones, faculty sponsor.

Mississippi Alpha, Mississippi University for Women, Columbus
Chapter President - Rissa Lawrence
12 actives

The Mississippi Alpha Chapter of KME hosted a reception for the parents of students in the Division of Science and Mathematics. KME also sponsored a campus wide game day. Dr. Jerry Reed, Professor of Mathematics at Mississippi State University, spoke at a KME sponsored seminar within the Division of Science and Mathematics. His topic was "Figures of Constant Breadth." Other 1986-87 officers: Denise Reynolds, vice president; Stephanie Snyder, secretary; Jean Ann Parra, corresponding secretary; Carol B. Ottinger, faculty sponsor.

Mississippi Gamma, University of Southern Mississippi, Hattiesburg
Chapter President - Stephanie Stotland
30 actives, 13 initiates

KME officers provided a spring newsletter for its members. The Freshman Mathematics Exam was given in February, produced and sponsored by KME. The spring initiation ceremony took place on April 17th at the home of Dr. and Mrs. Steve Doblin. Immediately following the ceremony, the members enjoyed an outdoor taco supper. Other 1986-87 officers: Amy Duvall, vice president; Joyce Deer, secretary; Alice Essary, corresponding secretary; Virginia Entrekin, faculty sponsor.

Missouri Alpha, Southwest Missouri State University, Springfield
Chapter President - Darlena Jones
60 actives, 16 initiates

Missouri Alpha held three regular meetings during the spring semester which included presentations by one student and two faculty members. A special meeting was held at which Dr. Joe Crosswhite, president of NCTM, spoke to those interested in mathematics. The chapter attended the regional meeting of KME held at Drury College. One student paper was presented from Missouri Alpha. Four students and three faculty attended the meetings. The semester was concluded with our annual spring banquet. Other 1986-87 officers: Doug Starkey, vice president; Lori Baskins, secretary; Kevin Keltner, treasurer; John Kubicek, corresponding secretary; Simon Bernau, faculty sponsor.

Missouri Epsilon; Central Methodist College, Fayette
Chapter President - Roberta Burger
3 actives, 6 initiates

Other 1986-87 officers: Christina Drummond, vice president; Malcolm Hower, secretary; Deborah Sellmeyer, treasurer; William D. McIntosh, corresponding secretary and faculty sponsor.

Missouri Gamma, William Jewell College, Liberty
Chapter President - Blane Baker
16 actives, 9 initiates

Regular monthly meetings were held each month during the year. A spring initiation and banquet were held with Mr. Gerald Eichhoefer as speaker. Other 1986-87 officers: Laurie Honeyfield, vice president; Remy Blanchaert, Jr., secretary; J. T. Mathis, treasurer, corresponding secretary and faculty sponsor.

Nebraska Alpha, Wayne State College, Wayne
Chapter President - Dana Hungerford
36 actives

To make money throughout the spring semester, club members have monitored the Mathematics and Science Building in the evenings and raffled off a television set, a clock radio, and a disc camera. Some of these funds, along with allocation money from the Wayne State College Student Senate, were used to purchase a color wheel printer. The club administered the annual test to identify the outstanding freshman majoring in mathematics. The award went to Rusty Sadler whose home is Calumet, Iowa. The award includes the recipient's name being engraved on a permanent plaque, payment of KME national dues, one year honorary membership in the local KME chapter, and announcement of the honor at the annual spring picnic. At the annual spring picnic, sponsor Dr. Hilbert Johs of the Mathematics Department was elected Outstanding Professor in the Mathematics-Science Division by secret ballot where students majoring or minoring in the sciences and mathematics are eligible to vote. The $25 book scholarships sponsored by the club were won by Gwen Hartman and Dana Hungerford. Members Steve Gedwillo, Dan Stalp, Doug Anderson, Dana Hungerford, Gwen Hartman, Kelli Krutz, Colleen Spieker, Kurt Meisinger and Professors James Paige and Fred Webber attended the Region IV KME Convention April 11-12, 1986, at Kearney State College in Kearney, Nebraska. Club members assisted the Wayne State College mathematics faculty with the Twelfth Annual WSC Mathematics Contest on May 12, 1986, kept the KME bulletin board current, and sponsored some social functions for club members. Other 1986-87 officers: Colleen Spieker, vice president; Karen Devine, secretary and treasurer; Kenneth Mestl, Historian; Fred Webber, corresponding secretary; James Paige

and Hilbert Johs, faculty sponsors.

Nebraska Beta, Kearney State College, Kearney
Chapter President - Mary Kay Weidner
19 actives, 6 initiates

Our chapter hosted a regional meeting with four chapters and two student papers on April 12, 1986. Other 1986-87 officers: Ann Stengel, vice president; Kim Jenkins, secretary; Craig Treptow, treasurer; Charles G. Pickens, corresponding secretary and faculty sponsor.

Nebraska Delta, Nebraska Wesleyan University, Lincoln
Chapter President - Sondra Rodabaugh
20 actives, 3 initiates

The Nebraska Delta Chapter of Kappa Mu Epsilon was installed on Friday, April 18, 1986, at Nebraska Wesleyan University. The installation ceremony was preceded by a banquet in the President's Dining Room of the Student Center. Dr. Melvin Thornton, Professor of Mathematics and Statistics at the University of Nebrasks, Lincoln, gave an entertaining and informative talk, entitled "Christopher Columbus and the Water-Wine Puzzle." Sr. Jo Ann Fellin of the Kansas Gamma Chapter, Benedictine College, Atchison, Kansas, was the installing officer. She presided at the installation of the Nebraska Delta Chapter and the initiation of twenty charter members. She presented the Charter and Crest to the club. The officers participating in the ceremony were: President - Julie Clopper, Vice President - Sondra Rodabaugh, Secretary - Alma Lowry, Treasurer - David Rushall, Faculty Advisor - Daniel Kaiser, Corresponding Secretary - Muriel Skoug. On May 4, 1986, three new members were initiated into the Chapter. The initiation ceremony was held during the annual spring picnic. The chapter met on April 23rd to select new officers. Other 1986-87 officers: Alma Lowry, vice president; Nancy Nichols, secretary; Nicole Austin, treasurer; Muriel Skoug, corresponding secretary; Daniel Kaiser, faculty sponsor.

Nebraska Gamma, Chadron State College, Chadron
Chapter President - Beth Kilday
18 actives, 6 initiates

Seven members chaperoned by Mr. James Kaus, corresponding secretary, attended the Region IV Convention in Kearney, Nebraska, on April 12, 1986. Beth Kilday presented a paper on "Graph Theory" and earned second place. Other 1986-87 officers: Rod Tyma, vice president; Donna Wehling, secretary; Deb Gaswick, treasurer; James Kaus, corresponding secretary; Monty Fickel, faculty sponsor.

New Mexico Alpha, University of New Mexico, Albuquerque
Chapter President - Cecilia DeBlasi

Other 1986-87 officers: Suzi Fehrenbach, vice president; Sheryl Henry, secretary; Richard Metzler, treasurer; Merle Mitchell, corresponding secretary and faculty sponsor.

New York Eta, Niagara University, Niagara

Most of the activity this semester centered around the planning of the initiation/banquet which was held this year in Niagara Falls, Canada, on April 25. The group was addressed by Mr. Michael Gallagher, alumnus and actuary, who spoke on the role of mathematics training in actuarial science. Chapter officers for 1986-87 will be elected during September, 1986. Robert L. Bailey is corresponding secretary.

New York Lambda, C. W. Post Center - Long Island University, Greenvale
Chapter President - Paula Punis
50 actives, 6 initiates

A talk was given by Donna Pirich who was a former mathematics major and graduate student at C. W. Post. She is currently a research scientist in the Nuclear Detection and Analysis Laboratory of Grumman Corporation. Her talk was on her experiences as a mathematician. Other 1986-87 officers: Cynthia Ferro, vice

president; Louis Sassano, secretary; Vida Moniriarani, treasurer; Annmary Esposito, historian; Sharon Kunoff, corresponding secretary and faculty sponsor.

Ohio Alpha, Bowling Green State University, Bowling Green
Chapter President - Kathy Raimer
10 actives, 30 initiates

November: Pizza Party; January: Talk on job opportunities by Prof. Waldamer Weber, Bowling Green State University; March and April: T-Shirt Sale, KME Initiation Banquet. Other 1986-87 officers: Carolyn Styer, vice president; Todd Hoadley, secretary; Rhonda Thomas, treasurer; Fred Leetch, corresponding secretary; Herb Hollister, faculty sponsor.

Ohio Zeta, Muskingum College, New Concord
Chapter President - Connie Garces
45 actives, 7 initiates

At the January 22nd meeting students Karen Linn, Kim Tran, and Lisa Elderbrock presented Putnam problems they had solved. The initiation of seven new members took place on February 19. Each initiate gave a short talk following the ceremony. On March 14 we hosted the Region II Convention. Four Muskingum students presented talks. The presenters were Pam Crooks, Cheryl Hetrick, Sharon Miller, and Doug Cantrell. New officers were elected on April 16. Following, Dr. Smith presented slides of Europe and spoke of the mathematics involved with the student trips he has taken. A cook-out was held at the home of Dr. Smith on May 4. At that time, freshman mathematics award winner, Greg Files, and senior award winner, Lisa Elderbrock, were recognized. Other 1986-87 officers: Bonnie Kieffer, vice president; Karen Linn, secretary; Fred List, treasurer; James L. Smith, corresponding secretary; Russ Smucker, faculty sponsor.

Oklahoma Alpha, Northeastern State University, Tahlequah
Chapter President - Anne Autrey
16 actives, 11 initiates

Other 1986-87 officers: Chris Denney, vice president; Patricia McGinn, secretary and treasurer; Joan E. Bell, corresponding secretary and faculty sponsor.

Pennsylvania Alpha, Westminster College, New Wilmington
Chapter President - Tracey L. Boyce
40 actives, 9 initiates

This spring we initiated nine new members into our chapter. We had a very nice banquet with a lot of support from old members. We also were pleased to have a graduate of Westminster and a member of our chapter speak. We ended our activities for the year with a picnic at a nearby park. Hiking and cooking out were the high points of the last gathering. Other 1986-87 officers: Karen L. Haney, vice president; Rhonda J. Smith, secretary; David R. Jarrett, treasurer; J. Miller Peck, corresponding secretary; Barbara T. Faires, faculty sponsor.

Pennsylvania Beta, LaSalle University, Philadelphia
Chapter President - Tony Altomare
21 actives, 9 initiates

A meeting was held on March 27 to initiate nine new members. Dr. Stephen Andrilli of the department spoke on using APL to study abstract algebra. A meeting was held on April 22 to elect new officers. Other 1986-87 officers: Edward Dzialo, vice president; Ken Olonovich, secretary; Tony Martella, treasurer; Hugh N. Albright, corresponding secretary; Carl McCarty, faculty sponsor.

Pennsylvania Delta, Marywood College, Scranton
10 actives, 6 initiates

A math contest (oral and written) for area high school students was held on April 12 and 27. Some members attended

the NCTM National Convention April 2-5. Chapter officers for 1986-87 will be elected in September, 1986. Sister Robert Ann von Ahnen is corresponding secretary and faculty sponsor.

Pennsylvania Epsilon, Kutztown University, Kutztown
Chapter President - Pamela J. Dotterer
22 actives, 7 initiates

We had student speakers at three of our meetings in conjunction with their practicum class in secondary education mathematics. Topics of these talks were: Mathematics and Music, Applications of a Property of the Ellipse in Medicine (for Busting Kidney Stones), Mathematical Properties Used in Construction of Viols. Michael Ecker of the University of Scranton spoke at our induction banquet. We will have a picnic for KME members together with Math and CIS faculty on the Saturday after final exams have been completed. Other 1986-87 officers: Kevin J. Olsen, vice president; Glen R. Naregang, secretary; Chad S. Benner, treasurer; William E. Jones, Jr., corresponding secretary; Edward W. Evans, faculty sponsor.

Pennsylvania Zeta, Indiana University of PA, Indiana
Chapter President - Anne Polito
34 actives, 11 initiates

Speakers for the spring semester were Dr. George Mitchell, KME faculty sponsor, and Dr. Harold Tompkins, member of the Computer Science Department faculty. A spring banquet was held in April. The delicious meal was prepared by Mr. and Mrs. Raymond Gibson with the assistance of KME members. Mr. Gibson was also the speaker. During the semester members collected used books from faculty members which were sold to raise funds to help defray expenses for members who will be attending the next national convention. Other 1986-87 officers: Lucy Sgrignoli, vice president; Bonnie Jacko, secretary; Daniel Besecker, treasurer; Ida Z. Arms, corresponding secretary; George Mitchell, faculty sponsor.

Pennsylvania Kappa, Holy Family College, Philadelphia
Chapter President - Nadine Hillgen
6 actives, 10 initiates

The highlight of the spring semester was a visit to The Franklin Institute for the math exhibit and the planetarium to view and learn about Halley's Comet. Sister Grace's lectures (Probability: Quantifying Chance, Mathematics on Postage Stamps) were well received and enjoyed by the members. Elaborate plans were made for installation of at least six math majors into KME on March 17, 1987. Other 1986-87 officers: Linda Rafferty, vice president and secretary; Susan Ciambrano, treasurer; Sister M. Grace, corresponding secretary and faculty sponsor.

Pennsylvania Lambda, Bloomsburg University, Bloomsburg

The 1986 Region I KME Convention was held at Frostburg State College on April 25-26, 1986, with the members of Maryland Delta Chapter as hosts. The convention began with a dinner meeting in the Lane Center on the Frostburg Campus at which Dr. James M. Landwehr of AT&T Bell Laboratories presented a talk entitled "Applications of Recent Ideas of Statistical Data Analysis in Industry." Following dinner participants gathered at the Mustard Seed for a sleuthing game. Registration was completed Saturday morning (April 26) with the following chapters in attendance: Maryland Delta (Frostburg State College), Pennsylvania Lambda (Bloomsburg University), Maryland Beta (Western Maryland), Pennsylvania Theta (Susquehanna), Pennsylvania Zeta (Indiana). Student talks were presented by Doris Cook of Susquehanna University, Scott Inch of Bloomsburg University, and Richard Zimmerman of Frostburg State College (graduate). After the student talks Frostburg professor, Dr. Edward White, proved he was the Pope in a talk entitled "1 = 2, It's True." An awards committee made up of students Pamela Weisgarber and Dan Burlett of Pennsylvania Zeta and faculty members James Lightner of Maryland Beta and George Mitchell of Pennsylvania Zeta met at the conclusion of the talks to decide on awards. In the undergraduate category, Scott Inch was given first place and Doris Cook was given second place. Richard Zimmerman was first in the graduate category. The awards were presented by Region I Director, James C. Pomfret of Bloomsburg University. Special thanks go to Teresa Neville, Chapter President, John Jones, Advisor and Don Shriner, Corresponding Secretary of Maryland Delta for the

quality job they did in organizing and running the convention. This report of the Region I Convention is respectfully submitted by James C. Pomfret, Region I Director and corresponding secretary of Pennsylvania Lambda.

Tennessee Delta, Carson-Newman College, Jefferson City
Chapter President - patricia Snowden
17 actives, 5 initiates

During the course of the semester our members viewed the MAWIS videotape "Mathematics in Space." The Initiation Banquet was held at the Little Dutch Restaurant in Morristown and the annual year-end picnic was held at Panther Creek State Park. Other 1986-87 officers: Gregory Ott, vice president; Elizabeth Nations, secretary; Bonnie Barnard, treasurer; Albert Myers, corresponding secretary; Carey Herring, faculty sponsor.

Tennessee Gamma, Union University, Jackson
Chapter President - Phillip Brewer
29 actives, 5 initiates

Other 1986-87 officers: Danny Evans, vice president; Melodi Myers, secretary; Beth Dennis, treasurer; Don R. Richard, corresponding secretary; Dwayne Jennings, faculty sponsor.

Texas Alpha, Texas Tech University, Lubbock
Chapter President - Warren Koepp
20 actives, 36 initiates

Our main activity during the spring semester was initiating 36 new members at our departmental banquet held on April 26th. Other 1986-87 officers: Cathy Cain, vice president; Mark Crawford, secretary; D. C. Murphy, treasurer; Robert Moreland, corresponding secretary and faculty sponsor.

Texas Eta, Hardin-Simmons University, Abilene
Chapter President - Stephanie Thomas
15 actives, 4 initiates

The Texas Eta Chapter of KME held its twelfth annual induction banquet February 28, 1986. There were four members inducted: Susan Bade from Clyde, Texas; John Dailey from Tyler, Texas; and Lisa Kimberling and Wayne Mixon from Abilene, Texas. With the induction of these members, membership in the local chapter stands at 98. Dr. John Peslak, professor of chemistry and physics at Hardin-Simmons University, addressed the chapter on the subject, "Nicholas Copernicus: The Problem with his Female Housekeeper." Leading the induction ceremonies were the 1985-86 KME officers: Laura Watson, president; Sam Shin, vice president; Stephanie Thomas, secretary; Mike Cagle, treasurer. Other 1986-87 officers: John Dailey, vice president; Mike Cagle, secretary and treasurer; Mary Wagner, corresponding secretary; Charles Robinson and Ed Hewett, faculty sponsors.

Virginia Beta, Radford University, Radford
Chapter President - Susan Morris
20 actives, 14 initiates

The initiation ceremony was held on March 6. The spring picnic took place on April 20. Other 1986-87 officers: Jim Campbell, vice president; Lisa Kemper, secretary; Michelle Skelton, treasurer; Coreen L. Mett, corresponding secretary; J. D. Hansard, faculty sponsor.

Wisconsin Alpha, Mount Mary College, Milwaukee
Chapter President - Ann Brandt
5 actives, 2 initiates

On April 27, 1986 two students were initiated into Wisconsin Alpha: Ann Brandt and Michelle Wielebski. Prior to initiation both students had made presentations to the chapter. Ann gave a talk on repeating decimals and some of their interesting properties. Michelle's presentation dealt with the properties of magic triangles. Other 1986-87 officers: Michelle Wielebski, vice president and treasurer; Ann Brandt, secretary; Sister Adrienne Eickman, corresponding secretary and faculty sponsor.

Wisconsin Beta, University of Wisconsin-River Falls, River Falls
Chapter President - Thomas Weber
20 actives, 18 initiates

A film festival was held in February. Two films were shown. A Problem-of-the-Month bulletin board was started in which each month a math problem was posted. The first person to solve each problem won a prize. Four KME members attended the Pi Mu Epsilon Mathematics Conference at St. John's University, Collegeville, MN in March. We have begun recreational math sessions on Fridays where students discuss math-related problems and games. Initiations were held in May. We had 18 initiates. Two speakers talked on "The Aftermath of a B.S. Education." Also, in May, we had a spring picnic with the computer science, chemistry, and physics organizations on campus. The picnic included a volleyball competition between the organizations. Other 1986-87 officers: Jody Speer, vice president; Janice Pete, secretary; Sarah Flood, treasurer; Lyle D. Oleson, corresponding secretary; Donald Leake, faculty sponsor.

Wisconsin Gamma, University of Wisconsin-Eau Claire, Eau Claire
Chapter President - Susan Haltlen
60 actives

The spring semester completed a successful year for the Wisconsin Gamma Chapter. At each of our monthly meetings we had one or more presentations given by student members of the club. Four members of the club traveled to the Region IV Convention at Kearney, Nebraska. Our vice president, John Svedberg, gave a presentation entitled "An Example of a Single Error Correcting Double Error Detecting Cyclic Code." His presentation was awarded first place. We had two fund-raisers, selling popcorn at the student union and a bake sale which was also held at the student union. They were both a success and provided the club with enough operating funds to help send representatives to Kearney, to have a year-end picnic, and to give next year's administration a start-up fund. It wasn't always work, as we had a couple social hours at a local college gathering spot and we ended the year with a picnic for members of the club, the math staff, and friends. Other 1986-87 officers: Lisa Swerman, vice president; Sarah Sass, secretary; Jim Fischer, treasurer; Tom Wineinger, corresponding secretary.

For Immediate Release

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(313)226-7928

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