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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.

WHEN IS A LATTICE A LATTICE?

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INTRODUCTION

Until my first course in modern algebra, my only association with lattices had been limited to the type found in rose gardens. According to the Merriam-Webster Dictionary, a lattice is "a framework of crossed wood or metal strips." In modern algebra, the integer points on the cartesian plane were also referred to as a lattice. Later, when I learned the formal definition of a lattice, I wondered why the integer points or the rose garden lattices were called lattices. So, the question I posed myself was: "When is a lattice a lattice?" This paper answers that question.

Before defining a lattice, we must establish some necessary tools. The first of these is a partially ordered set. *A partially ordered set* is a relation, R (frequently denoted by $\geq$), on a set, P, such that R is reflexive, antisymmetric, and transitive.[1] We denote a partially ordered set by $(P, \geq)$ or simply P. Consider Figure 1 with $P = \{a,b,c,d,e\}$ and the relation $\geq$ where $x \geq y$ if and only if (iff) $x = y$ or x is connected to y by a descending line. Such a figure is usually called a Hasse diagram and will be used throughout this paper.

[1] Most of the definitions, statements of theorems, and general sketches of theorems found in this paper come from *Lectures in Abstract Algebra* Vol. I by Jacobson and *Introduction to Lattice Theory* by Rutherford.

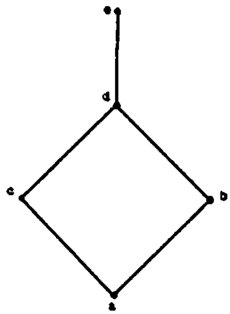

Figure 1

This relation is reflexive since x, $x \geq x$. It is antisymmetric because the only time $x \geq y$ and $y \geq x$ is when $x = y$. The relation is also transitive since $x \geq y$ and $y \geq z$ implies $x \geq z$. Therefore, $P = \{P, \geq\}$ is a partially ordered (p.o) set.

Next, we consider chains and covers of elements of a p.o. set. A p.o. set, P, is a *chain* if every pair of elements (a,b) of P are comparable,that is either $a \geq b$ or $b \geq a$. The set {e,d,c,a} in Figure 1 forms a chain. Figure 2 represents a p.o. set on subsets of {1,2,3,4} with the relation: x is a subset of y iff x is connected to y by a rising line. In Figure 2, the set {(1,2,3,4),(1,2,4),(2,4),(2),(∅)} is a chain. The set {(1,2,3,4),(2,3,4),(1,2)} does not form a chain in Figure 2 since (2,3,4) is not related to (1,2) nor is (1,2) related to (2,3,4).

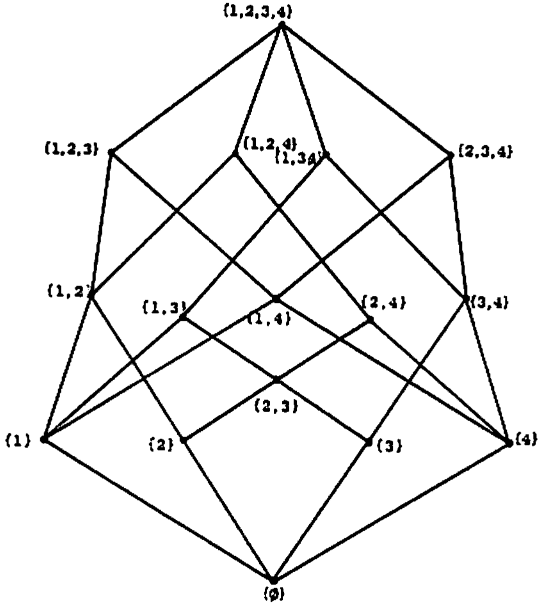

Figure 2

Let x and y be elements of a p.o. set P. Then we say x *covers* y if x > y (i.e. x $\geq$ y but x $\neq$ y) and there does not exist an element, z, of P such that x > z > y. By referring back to Figure 1 we can see that element e covers d but e does not cover b,c or a. Element d covers b and c,but d does not cover a or e. The elements b and c cover a but they do not cover each other, d or e.

Let P be a p.o. set. An element x in P is an *upper bound* for a nonempty subset A of P iff x $\geq$ a for every a in A. An element x in P is a *least upper bound* (l.u.b.) for A _ P iff x is an upper bound and $y \geq x$ for any upper bound y of A. Similar definitions hold for *lower bound* and *greatest lower bound* (g.l.b.) If x and y are in P, we write x U y and x y to denote the l.u.b. and g.l.b. of the set {x,y} respectively (i.e. if they exist).

Now we are prepared to define a lattice.

FORMAL LATTICES

DEFINITION. A p.o. set, L, is a *lattice* if any two elements of L possess a least upper bound and a greatest lower bound. For the p.o. set P of Figure 1 we have:

elements	l.u.b.	g.l.b.
a,b,	b	a
a,c	c	a
b,c	d	a
c,d	d	c
b,d	d	b
a,d	d	a
a,e	e	a
c,e	e	c
b,e	e	b
d,e	e	d

By checking all possibilities, we have proven that the set P of Figure 1 does form a lattice. Figure 3 with the usual interpretation of the connecting lines is not a lattice since the elements a and b do not have a greatest lower bound.

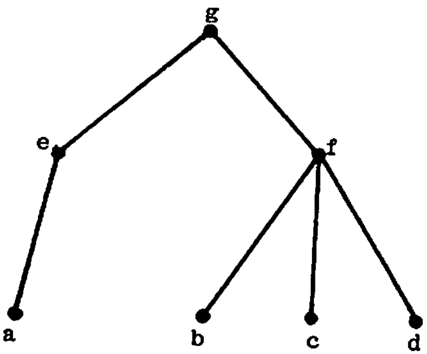

Figure 3

KINDS OF LATTICES

DEFINITION. A lattice L is a *complete* lattice if every non-empty (finite or infinite) subset of L has a greatest lower bound and a least upper bound. Figure 1 is a complete lattice since every subset of L={a,b,c,d,e} has a g.l.b. and a l.u.b.

Not all lattices are complete; however we have:
Theorem: A lattice without infinite chains is complete.[1]

For computational purposes we need to know identities. In this light we have:

DEFINITION. A lattice L is *modular* if all x,y,z in L, whenever $x \geq z$, we can conclude $x \cap (y \cup z) = (x \cap y) \cup z$.
Example: The lattice described in Figure 4 is modular.

[1]Rutherford, p. 8.

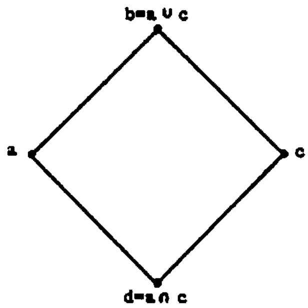

Figure 4

Clearly Figure 4 represents a lattice. We need to show it is modular.

For $b \geq c$ we have:

$$b \cap (a \cup c) = b \cap b = b; \quad (b \cap a) \cup c = a \cup c = b;$$

hence $$b \cap (a \cup c) = (b \cap a) \cup c .$$

In similar manner, the reader can complete the proof for $a \geq d$, $c \geq d$, $b \geq a$ and $b \geq d$. Therefore, for every choice of x, y, and z in L, we have if $x \geq z$ then $x \cap (y \cup z) = (x \cap y) \cup z$. Hence Figure 4 represents a modular lattice.

Not all lattices are modular. The lattice described in Figure 5 is not modular. Since, even though $c \geq b$, we have $c \cap (a \cup b) = c \cap I = c$. But $(c \cap a) \cup b = 0 \cup b = b$, and $b \neq c$. Therefore this lattice is not modular.

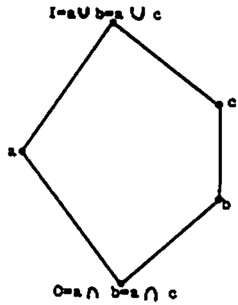

Figure 5

<u>DEFINITION</u>. Two lattices L and M are *isomorphic* if there exists a 1-1 and onto mapping ϕ of L onto M such that a $\geq$ b in L implies and is implied by $\phi(a) \geq \phi(b)$ in M.[1]

Now we have a way to identify modular lattices:

<u>Theorem</u>: A lattice is modular iff it contains no sublattice isomorphic to the pentagonal lattice of Figure 5.[2]

The reader can readily prove one direction of this theorem by supposing a lattice contains a sublattice isomorphic to the pentagonal one. For the other direction, see Rutherford.

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[1]Jacobson, p. 192.

[2]Rutherford, p. 13.

Some lattices satisfy even stronger identities than the modular one. For example:

<u>DEFINITION</u>. Let L be a lattice and x,y,z be elements of L. L is *distributive* if it satisfies:

$(x \cap y) \cup (y \cap z) \cup (z \cap x) = (x \cup y) \cap (y \cup z) \cap (z \cup x)$.[1]

Then we have

<u>Theorem</u>: Every distributive lattice is modular.[2]

Let L be a distributive lattice. If $x \geq y$, then $x \cap y = y$ and $x \cup y = x$. By making these substitutions into the distributive lattice identity, the reader will arrive at the identity for a modular lattice.

The above is not surprising because one can prove that for L a lattice and x,y,z elements of L, L is distributive if and only if it satisfies:

1) $x \cup (y \cap z) = (x \cup y) \cap (x \cup z)$

and 2) $x \cap (y \cup z) = (x \cap y) \cup (x \cap z)$.

The reader can show that the two formulations are equivalent.

<u>WHEN IS A LATTICE A LATTICE?</u>

Now I am finally ready to pursue my original question. Let's look at the set of all integer points of the

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[1] Rutherford, p. 22.

[2] <u>Ibid</u>., p. 22.

Euclidean plane, say T. In attempting to discover a relation between the integer points that would make this plane a lattice, I made many false starts. Then I discovered an interesting relation.

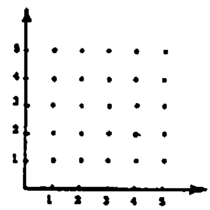

Figure 6

I let (a,b) and (c,d) be two integer points on the Euclidean plane, T, (Figure 6). In order to establish a partial ordering, $\leq$, on T, let e = l.c.m.(a,b) and f = l.c.m.(c,d). Then define (a,b) $\geq$ (c,d) iff e $\geq$ f. It can be shown that although this relation on T is reflexive, and transitive, it is not antisymmetric (for (2,3) $\geq$ (3,2) and (3,2),(2,3) but (2,3) $\neq$ (3,2).) Hence we do not even have a partial ordering on T with this definition of ' $\leq$ '.

After more searching, I found another less cumbersome relation on T that does form a lattice. For points (a,b) and (c,d), I define:

(a,b) > (c,d) iff b > d, or a > c and b = d;

(a,b) = (c,d) iff a = c and b = d.

This relation proved to be reflexive and antisymmetric, and by examination of the four cases resulting from our definition it is easy to show it is transitive. Hence $\geq$ partially orders T. Further, I defined $\cap$ and $\cup$, g.l.b. and l.u.b. respectively, to be:

$$(a,b) \cap (c,d) = (\min.(a,c), \min.(b,d))$$

$$(a,b) \cup (c,d) = (\max.(a,c), \max.(b,d))$$

For example take the points (1,4) and (2,3).

$$(1,4) \cap (2,3) = (1,3). \quad (1,4) \cup (2,3) = (2,4).$$

The minimum and maximum values always exist among two integers. It follows then, that the g.l.b. ($\cap$) and l.u.b. ($\cup$) always exist for any two elements in T. Therefore T is a lattice.

T is not a complete lattice since the infinite subset {(1,2),(1,3),(,4),...} does not have a l.u.b.

To show T is modular we must prove: if x,y,z in T and $x \geq z$, then $x \cap (y \cup z) = (x \cap y) \cup z$. Consider the following six cases:

1) $x > y > z$. $x \cap (y \cup z) = x \cap y = y$

$(x \cap y) \cup z = y \cup z = y$ & $y = y$.

2) $x > z > y$. $x \cap (y \cup z) = x \cap z = z$

$(x \cap y) \cup z = y \cup z = z$ & $z = z$.

3) $y > x > z$. $x \cap (y \cup z) = x \cap y = x$

$(x \cap y) \cup z = x \cup z = x$ & $x = x$.

4) $x = z > y$. $x \cap (y \cup z) = x \cap z = x = z$

$(x \cap y) \cup z = y \cup z = z$ & $z = z$.

5) $x = z = y$. $x \cap (y \cup z) = x \cap y = x$

$(x \cap y) \cup z = x \cup z = x$ & $x = x$.

6) $y > x = z$. $x \cap (y \cup z) = x \cap y = x$

$(x \cap y) \cup z = x \cup z = x$ & $x = x$.

Therefore T is modular. Of course T can also be shown to be modular because it contains no sublattice isomorphic to the pentagonal lattice.

T is a modular lattice and we can show this by, either checking the identity $x \cap (y \cup z) = (x \cap y) \cup (x \cap z)$ for $x \geq z$, or showing no sublattice of T is isomorphic to the pentagonal lattice. However, it turns out that T is in fact distributive and therefore modular by a previous theorem. We prove T is distributive. Let $x = (a,b)$, $y = (c,d)$, $z = (e,f)$. Then:

$x \cap y = (\min.(a,c), \min.(b,d))$,

$y \cap z = (\min.(c,e), \min.(d,f))$, and

$z \cap x = (\min.(a,e), \min.(b,f))$.

It follows that $x \cap (y \cup z) = x \cap (\max.(c,e), \max.(d,f))$

$= [\min.(a, \max.(c,e)), \min.(b, \max.(d,f))]$.

But $(x \cap y) \cup (x \cap z)$

$= [\min.(a,c), \min.(b,d)] \cup [\min.(a,e), \min.(a,f)]$

$= [\max.(\min.(a,c), \min.(a,e)), \max.(\min.(b,d), \min.(a,f)]$.

By examining the six orderings of b,d,f and the six orderings of a,c,e we can show that

$$x \cap (y \cup z) = (x \cap y) \cup (x \cap z)$$

and

$$x \cup (y \cap z) = (x \cup y) \cap (x \cup z).$$

Thus T is distributive.

My curiosity was satisfied once I had proven the set of integer points of the Euclidean plane was a modular distributive lattice. I had made a "lattice" into a lattice! However, as the result of further research, I came upon the concept of *direct product* of lattices. It caught my interest so I pursued it. This concept allows us to combine lattices; for example, to form a box into a lattice, we may take S and W two p.o. sets and form SXW. See Figure 7.

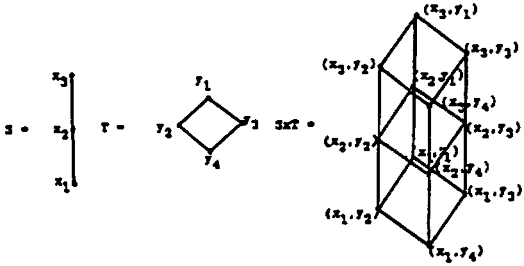

Figure 7

Formally, let S and W be lattices with $\cup_s, \cap_s$ operations in S and $\cup_w, \cap_w$ operations in W. Consider SXW, the usual cross product space. Then define operations $\cap_x, \cup_x$ in SXW as follows:

$$(x_1,y_1) \cup_x (x_2,y_2) = (x_1 \cup_s x_2, y_1 \cup_w y_2)$$

and

$$(x_1,y_1) \cap_x (x_2,y_2) = (x_1 \cap_s x_2, y_1 \cap_w y_2).$$

Now if $S = W = \mathbb{N}$ with the usual ordering we have SXW = T, the lattice of interest. Here $\cup_s$ and $\cup_w$ correspond to taking min. in $\mathbb{N}$ and $\cap_s$ and $\cap_w$ correspond to taking max. Also $\cup_x$ and $\cap_x$ correspond to l.u.b. and g.l.b. in T respectively. Hence, for $S = W = \mathbb{N}$, the direct product precisely produces my definition of a lattice on the Euclidean plane T.

It was nice to realize I had been able to make a lattice into a lattice.

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[3] Dubisch, Roy. Lattices to Logic. New York: Blaisdell Publishing Co., 1964.

[4] Jacobson, Nathan. Lectures in Abstract Algebra, Volume I. New Jersey: D. Van Nostrand Co., Inc., 1951.

[5] Rutherford, D. E. Introduction to Lattice Theory. New York: Hafner Publishing Co., 1965.

THE PLOWSHARE PROBLEM

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This paper deals with the application of mathematics to a problem which occurred in the steel industry. John Deere planned to convert its English dimension plows to new metric ones. Wisconsin Steel Company, which produces the parts for John Deere, needed precise dimension checks to produce the new plowshares. Inaccuracy would cause two things to occur, making the plowshare useless. First, if the plowshare were too large, the material would overfill the die during a forging process at the John Deere plant. Second, if the plowshare were too small, the metal would slip from the clamp during assembly. The problem arose when the steel company could not find these essential dimensions. In this paper the dimensions for the smallest of twelve different shares is studied; dimensions for the larger shares can be found in an analogous manner.

After examining the blueprint (found in Exhibit I in the appendix), the plowshare could be decomposed into four basic important parts. Two are circles of radii 370 (all dimensions are in centimeters), a third is another circle of radius 40, and the fourth is the line tangent to the circle of radius 40 and one of the circles of radii 370. The distances needed for the dimension checks were located along these figures. If after coordinatizing the share, the equations for each basic component could be found, then the distance computation would simply be the difference in the ordinates of two points (since each critical distance is measured vertically).

The easiest method of attack was to place the plowshare on a Cartesian coordinate plane using the information given on the blueprint. A brief analysis of the blueprint led to the equations of the circle of radius 40 and one of the circles of radius 370. That meant that only two equations needed work.

The first problem was to find the equation of the remaining circle. This was not very difficult since two points on the circle were known; the two equations to be solved simultaneously were:

$$(1)\qquad \begin{aligned} (55.8 - h)^2 + (19.7 - k)^2 &= 370^2 \\ (118.3 - h)^2 + (2.9 - k)^2 &= 370^2. \end{aligned}$$

The second problem dealt with the tangent line. This led to four equations in four unknowns. Let the point tangent to the circle of radius 370 be (x,y), and the point tangent to the smaller circle of radius 40 be (z,w). The first equation below is that of the circle of radius 370. The second one is the equation which equates the derivatives at the two points of tangency (A calculation of these derivatives is included in Exhibit II in the appendix). The third equation is the equation for the circle of radius 40, and the fourth is an equation which equates the slope of the tangent line with the derivative at one of the points of tangency (We used the point (z,w);(x,y) would have worked as well). In summary, the four equations are:

$$(2)\quad \begin{aligned} &\text{(i)} \quad (x - 3.3)^2 + (y - 358.585)^2 = 370^2 \\ &\text{(ii)} \quad (z - 109.863)^2 + (w - 40)^2 = 40^2 \\ &\text{(iii)} \quad \frac{3.3 - x}{y + 358.585} = \frac{109.863 - z}{w - 40} \\ &\text{(iv)} \quad \frac{y - w}{x - z} = \frac{109.863 - z}{w - 40} \end{aligned}$$

Once the systems of equations, (1) and (2), were found, it seemed reasonable to solve them on the computer. However, computer solutions were not possible in both cases, and that is what makes the problem very interesting. The computer easily solved the first problem. The center of the circle of radius 370 was found to be (187.729, 367.247). But, regarding the second problem, the computer kept sending out error messages. Upon tracing the program, the source of the error was discovered to be in an iterative procedure involving division by a Jacobian which became unacceptably small. Hence, any further effort along these lines using the computer would be futile.

The only possible progress would be made by manually solving or changing the form of the second system of equations. This was accomplished in six steps (the actual computations may be found in Exhibit III in the appendix). The first step simplified the equations by making a variable substitution. Then, utilizing the form of the first and third equations, the second step involved a polar coordinate transformation. Let θ be the polar angle measured with the pole at (x,y) and ϕ be the polar angle measured with the pole at (z,w). Now, either $\theta = \phi$ or $\phi = \theta + \pi$. After working out both cases, the results from each, when compared to the Cartesian coordinate plane, showed that $\phi = \theta + \pi$. This affects the transformation by making the z and w terms negative.

The third step is a series of algebraic manipulations and simplifications to reduce the fourth equation to quadratic form. To accomplish this, first cross multiply to eliminate the denominators (both of them are nonzero), and then make the appropriate polar transformation using the trigonometric substitution. We also square both sides. The terms are then grouped by coefficients and factored in order to simplify the equation using the trigonometric identity that $\sin^2\theta + \cos^2\theta = 1$. We then divide through by r (r = 40) and square both sides. Finally, all terms are converted to those involving $\sin\theta$ by making the substitution $\cos^2\theta = 1-\sin^2\theta$, and upon multiplying out all terms and moving them to one side, the equation becomes quadratic in $\sin\theta$.

The fourth step is to solve this quadratic. First we divide by the constant coefficient on the square term, substitute S for $\sin\theta$, and determine the numerical value of all the coefficients including the constant term. Using the quadratic formula, we find the two roots of the equation, and compare the value of the expression $X = R\sin\theta$ using each root. Although both values yield solutions to system (2), only one root (the smaller one) gives valid plowshare dimensions.

The final step is to begin working backwards; that is, we calculate the values of X,Y,Z, and W using the appropriate root found in step four described above. These values are then substituted into the appropriate formulas to find the coordinates (x,y) and (z,w). The point-slope form of the tangent line, in its final form, is:

$$y - 7.3009831 = -.150380487(x - 58.32224468)$$

Since the second problem is solved, the completion of the project is dependent upon finding the five vertical distances (see Exhibit IV in the appendix). The x coordinates of all the necessary points are given (by Wisconsin Steel Corporation on the blueprint), so what remains is to substitute each of these x values into each pair of equations, solve for the corresponding y values, and subtract these y values to obtain each critical distance.

It is interesting to note that the method used to determine the dimension checks was also used to calculate similar checks for the other plowshare sizes (with the appropriate change in constants). Recall too that this problem resisted efforts using elementary computer-based techniques.

EXHIBIT I

Wisconsin Steel Corporation Blueprint

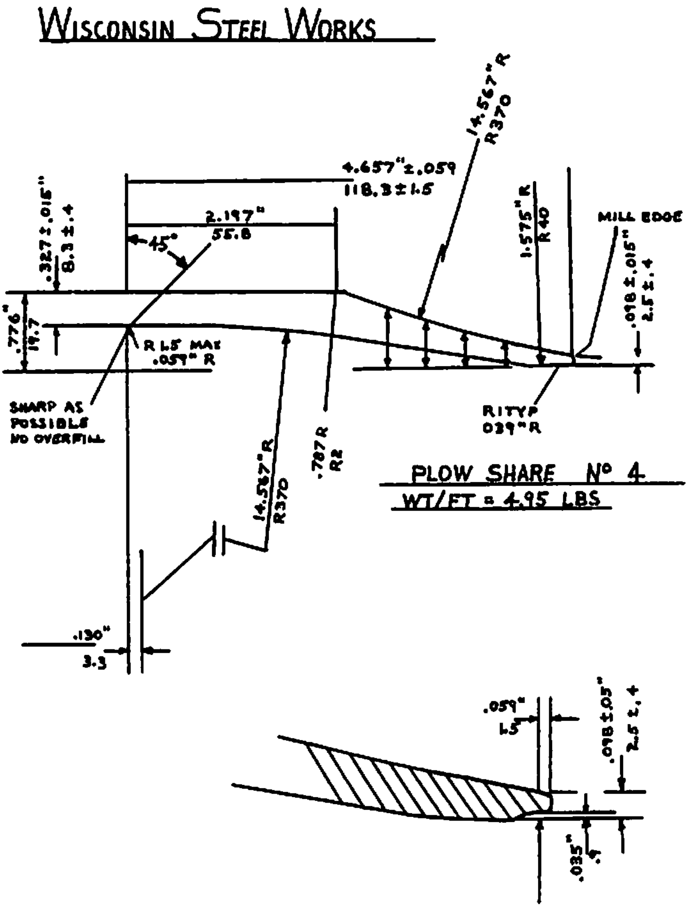


EXHIBIT II

Calculating Slopes of the Common Tangent Line.

Equation (i)

$$(x-3.3)^2+(y+358.585)^2=370^2$$

Equation (ii)

$$(z-109.863)^2+(w-40)^2=40^2$$

First we differentiate each equation implicitly, to get:

$$2(x-3.3)+2(y+358.585)(dy/dx)=0$$

and

$$2(z-109.863)+2(w-40)(dw/dz)=0$$

We then solve each equation for the derivatives, dy/dx and dw/dz respectively.

$$dy/dx = \frac{3.3-x}{y+358.585} \quad \text{and} \quad dw/dz = \frac{109.863-z}{w-40}$$

Since each of these derivatives is the slope of the common tangent line, we set them equal to each other to get Equation (iii).

Equation (iii)

$$\frac{3.3-x}{y+358.585} = \frac{109.863-z}{w-40}$$

EXHIBIT III

Solving System (2)

Step 1: Variable substitution

Let:

$X = x-3.3$	$a= -3.3$	$R = 370$
$Y = y+358.585$	$b= 358.585$	$r = 40$
$Z = z-109.863$	$c= -109.863$	
$W = w-40$	$d= -40$	

Then, Equations (i)-(iv) become

(i) $X^2+Y^2 = R^2$

(ii) $Z^2+W^2 = r^2$

(iii) $-X/Y = -Z/W$

(iv) $\frac{Y+b-W-d}{X+a-Z-c} = -\frac{Z}{W}$, or $YW+bW-W^2-dW=Z^2+cZ-XZ-aZ$

Step 2: Polar substititions

For Equation (i) let:

$X = R\sin\Theta$

$Y = R\cos\Theta$

For Equation (ii) let:

$Z = r\sin\phi$

$W = r\cos\phi$

From Equation (iii) (and the physical properties of the plowshare) we note that $\phi = \Theta + \pi$, so that

$$Z = -r\sin\Theta$$

$$W = -r\cos\Theta$$

Equation (iv) then becomes:

$$-rR\cos^2\Theta-br\cos\Theta-r^2\cos^2\Theta+dr\cos\Theta =$$
$$r^2\sin^2\Theta-cr\sin\Theta+rR\sin^2\Theta+ar\sin\Theta$$

Step 3: Reducing to a Quadratic Equation

Using the fact that $\sin^2\theta+\cos^2\theta = 1$ and dividing by r, Equation (iv) becomes:

$$-rb\cos\theta+rd\cos\theta = -rc\sin\theta+ra\sin\theta+rR+r,$$

or

$$(d-b)\cos\theta = (a-c)\sin\theta+(R+r)$$

We then square both sides and again use the identity $\sin^2\theta+\cos^2\theta = 1$ to get:

$$(d-b)^2(1-\sin^2\theta) = (a-c)^2\sin^2\theta+2(a-c)(R+r)\sin\theta+(R+r)^2$$

Finally, we let $S = \sin\theta$ and group terms to get the following quadratic equation.

$$0 = [(a-c)^2+(d-b)^2]S^2+2(a-c)(R+r)S+[(R+r)^2-(d-b)^2]$$

After calculating the constants and dividing by the leading coefficient this becomes:

$$0 = S^2-.51333S+.05422$$

Step 4: Solving the Quadratic

The Quadratic Equation gives two roots to this equation:

$$S=.36462 \quad \text{or} \quad S = .14871$$

The physical properties of the plowshare dictate that the smaller of these two is the root we want.

Step 5: Final Calculations

$$X = RS = R\sin\Theta, \text{ so}$$

$$X = 370(.1481)$$

$$= 55.022$$

Similarly,

$$Y = 365.886$$

$$Z = -\ 5.948$$

$$W = -39.555$$

Now, using the relationship, X+a=x, we can calculate x.

$$x = 58.322$$

Similarly,

$$y = 7.301$$

$$z = 103.915$$

$$w = .445$$

Step 6: The Equation of the Tangent Line

The two points on the tangent line are

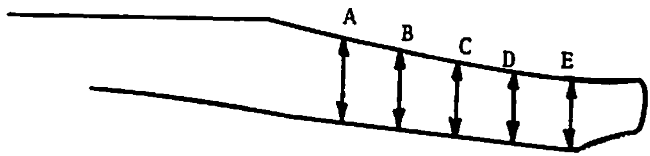
(x,y) = (58.322,7.301) and (z,w) = (103.915,.445).

We can easily compute the slope of this line, and (using the first point) subsequently get the "point-slope" form of the line itself.

$$y-7.301 = -.150(x-58.322).$$

EXHIBIT IV

Computation of Dimension Check Distances



Length of Segment E

The endpoints of E both lie on circles. The upper endpoint lies on a circle of radius 370, whose equation can be found using information listed on the blueprint. This equation is:

(*) $$(x-182.729)^2+(y-367.247)^2 = 370^2$$

The lower endpoint lies on the circle of radius 40 (Equation (ii)) which is:

(**) $$(x-109.863)^2+(y-40)^2 = 40^2$$

The x-coordinate at each endpoint (E is vertical) is found using blueprint information. Specifically,

$$x_0 = 118.3-6.35 = 111.95$$

The y-value of the upper endpoint can be calculated by substituting x_0 into Equation (*). It is

$$y_1 = 4.080$$

Similarly, the y-value of the lower endpoint can be computed by substituting x_0 into Equation (**). It is

$$y_2 = .055$$

The length of E is then $y_1 - y_2$ or E = 4.025.

The remaining lengths are found in a similar way with the exception that the lower endpoint of segments A,B, and C lie on the tangent line whose equation we worked so hard to get in Step 6 of Exhibit III. The complete list of dimension check lengths is below.

Segment	Length
A	6.910
B	6.216
C	6.198
D	5.148
E	4.025

TESSELLATIONS

DONALD D. SANDMAN
Student, Stevens Point, Wisconsin

Tessellations are pictures or designs that are created by filling up a surface with congruent figures, such that they do not overlap or leave any open spaces. When investigating the history of tessellations three names are prominent. These are M. C. Escher, Ernest Ranucci, and Joseph Teeters. The mathematics involved in tessellations is that of transformations. In essence, tessellations are mathematical works of art.

Congruent figures are one of the requirements for creating tessellations. Some regular polygons, such as equilateral triangles, squares, and hexagons may be tessellated. Some congruent nonregular polygons or figures can also be used to tessellate a surface. In addition to requiring congruent figures, these figures cannot overlap or leave any open spaces. Therefore, at any intersection point of the figures, the sum of the interior angles must equal three hundred sixty degrees. One regular polygon that will not tessellate is a pentagon. Each of its interior angles is one hundred eight degrees. See Figure 1.

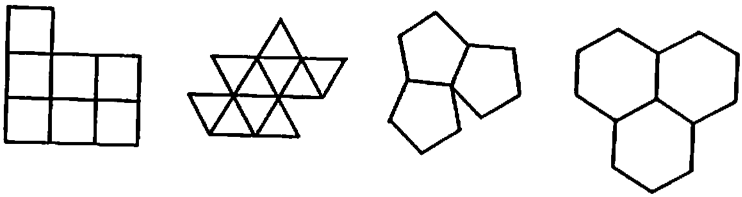


Figure 1

The historical aspect of tessellations is mostly artistic. The most prominent name, with respect to the creation of tessellations, is M. C. Escher. Escher was a Dutch painter and not a mathematician. He learned graphic techniques and the art of woodcut at an early age. Escher did most of his art work in the Netherlands and in Italy. Before 1937 his art work was very similar to the other artist's at that time. However, in 1936 Escher came in contact with the works of Moorish artists. Their mosaics fascinated and inspired him. With respect to this art work Escher once wrote,

> This is the richest source of inspiration that I have ever struck; nor has it yet dried up ... a surface can be regularly divided into, or filled up with, similar-shaped figures, which are contiguous to each other, without leaving any open spaces. The Moors were past masters of

> this. They decorated walls and floors ... by placing congruent, multicolored pieces of (tiles) ... together without leaving any spaces between ... They always restricted themselves ... to designs of an abstract geometrical type. Not one signle Moorish artist ... ever made so bold (a move) as to use concrete, naturalistically conceived figures of fish, birds, reptiles, or human beings as elements in their surface coverage. This restriction is all the more unacceptable to me in that the recognizability of the components of my own designs is the reason for my unfailing interest in this sphere.

From 1937 to 1944,Escher's work centered primarily around tessellations. During his life, Escher designed about one hundred fifty tessellations. Some of Escher's more famous woodcuts involving tessellations are "Night and Day", "Sky and Water", "Fish and Scales", and "Reptiles".

Ranucci and Teeters are two more recent, prominent names in tessellations. They are co-authors of a book, entitled Creating Tessellations. Ernest Ranucci died recently and was a professor at the State University of New York at Albany. Dr. Joseph Teeters is presently a professor at the University of Wisconsin - Eau Claire. Both men have written articles on tessellations for the publication, Mathematics Teacher. (See references at the end.)

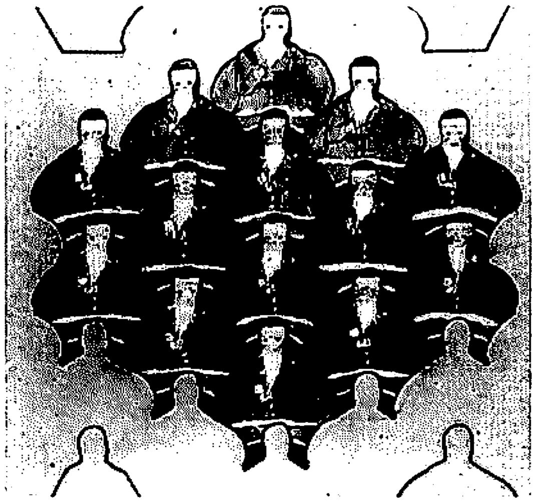


Figure 2

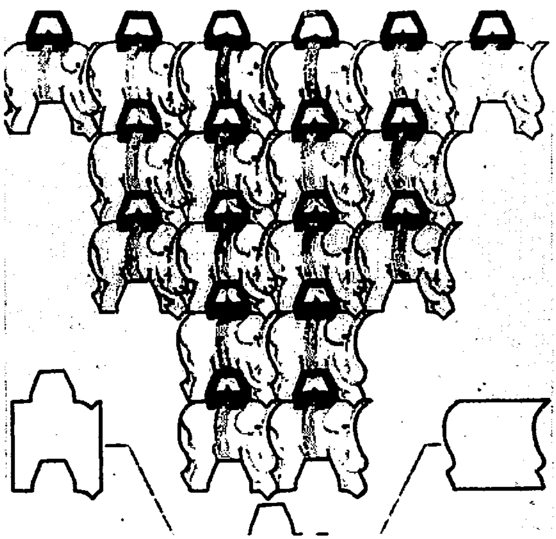


Figure 3

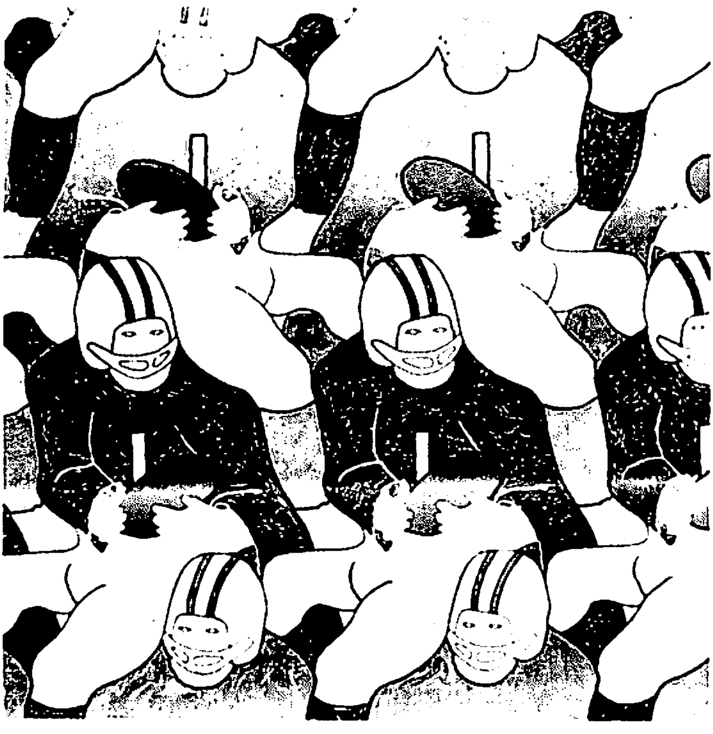


Figure 4

The mathematics involved in creating tessellations is that of transformations. The transformations used are translations, reflections and rotations. The designs in Figures 2 and 3 are my own creations and are examples of using translations to create tessellations. For Figure 2, I began with a square and used translations to subtract the same area as I added to the opposite side. For Figure 3, I began with a hexagon and again used translations on opposite sides.

Figure 4 is a tessellation, which is designed by using reflections and rotations and was created by Dr. Teeters. He began with a triangle, say triangle ABC. Taking M as the midpoint of AC, you start by sketching in a curve from A to M. This can be reflected about

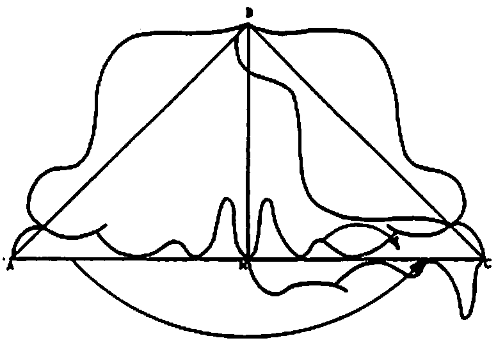


Figure 5

the line MB and then rotated about the midpoint between M and C. Thus the area we subtracted above was added below. Next vou sketch the curve from A to B. You then reflect that about line $\overline{MB}$ and rotate it about the midpoint between B and C. (See Figure 5.)

Tessellations are,in essence, beautiful mathematical works of art. In fact the Hodag Shopper, a newspaper from Rhinelander, Wisconsin for advertisements, printed a variation of Escher's "Sky and Water" on the front page of the fall 1978 issue. Insight seems to play an important role in creating tessellations,once one is familiar with the basic ground rules. The creation of tessellations using recognizable figures can be somewhat challenging.

References

[1] Escher, M. C., The Graphic Work of M.C. Escher,New York: Hawthorne Books, 1970.

[2] Escher, M.C. and J.L. Locher, The World of M.C. Escher, New York: Harry N. Abrams, Inc. 1971.

[3] Ranucci, Ernest, "Master of Tessellations: M.C. Escher, 1898-1972,Mathematics Teacher, April 1974, pp. 299-306.

[4] Ranucci, Ernest and Joseph Teeters, Creating Tessellations, 1977.

[5] Teeters, Joseph L., "How to Draw Tessellations of the Escher Type", Mathematics Teacher, April 1974, pp. 307-310.

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 1 February, 1981. The solutions will be published in the Spring 1981 issue of *The Pentagon*, with credit being given for other solutions received. Preference will be given to student solutions. Affirmation of student status and school should be included with solutions. Address all communications to Kenneth M. Wilke, Department of Mathematics, 275 Morgan Hall, Washburn University, Topeka, Kansas 66621.

PROPOSED PROBLEMS

Problem 327. Proposed by the editor.

Young Leslie Morely, while participating in a stock-car race, noticed a peculiar fact as he sped around the oval track. He noticed that 5/12 of the number of racers in front of him plus 3/5 of the number of racers behind him add up to the total number of participants in the race. If Leslie Morely placed second, how many racers did he beat?

Problem 328. Proposed by Robert A. Stump, Hopewell, Virginia.

Evaluate $\prod_{i=k+1}^{\infty} \frac{i^2-k^2}{i^2}$ where k is any positive integer.

Problem 329. Proposed by Charles W. Trigg, San Diego, California.

Find the length of the diagonals of both a regular pentagon and a regular hexagon in terms of the sides of the respective polygons without the aid of explicit or implicit functions of angles. (The Pythagorean theorem is an implicit function of 90°.)

Problem 330. Proposed by Robert A. Stump, Hopewell, Virginia.

Prove that every integer (positive, negative or zero) can be expressed as the sum of at most five integer cubes.

Problem 331. Proposed by Willie S. M. Yong, Republic of Singapore.

The numbers A, B and C each contain three digits and each of the non-zero digits appear exactly once in A, B or C. Each digit of A is less than the corresponding digit of B. If A+B = C and C is a power of a prime, find the values of A, B and C.

SOLUTIONS

317. *Proposed by John A. Winterink, Albuquerque Technical Vocational Institute, Albuquerque, New Mexico.*

In the figure, arc ABC has a measure of $\frac{5}{6}$ radians (or 150°) and its center at D. If AB= $\sqrt{3}$ and BC= $\sqrt{2}$, what is the value of cot ($\frac{1}{2}\angle$ BDC)?

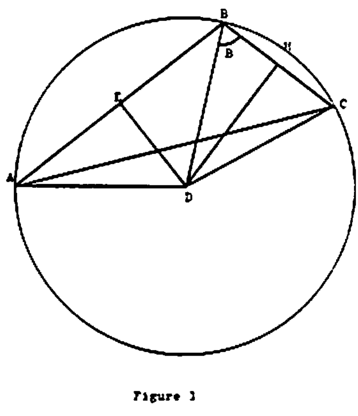


Figure 1

Solution by Fred A. Miller, Elkins, West Virginia.

Let DA = DB = DC = r and $\angle$ BDC = θ. Let M be the midpoint of BC and draw DM and AC. Then $\angle$ADC=150°, $\angle$ ABC = 105° and DM = $\sqrt{r^2-1} = \cot\frac{\theta}{2}$. Applying the law of cosines to $\triangle$ADC we get

$$AC^2 = 2r^2 - 2r^2\cos 150^\circ = r^2(2+\sqrt{3}). \qquad (1).$$

Similarly in $\triangle$ABC we obtain

$$AC^2 = 3^2 + 2^2 - 12\cos 105^\circ = 13 + 12\cos 75^\circ$$

$$= 13 + 3(\sqrt{6} - \sqrt{2}) \qquad (2).$$

Equating values of AC^2 we obtain

$$r^2 = \frac{13+3\sqrt{6} - 3\sqrt{2}}{2+\sqrt{3}} = 26 - 13\sqrt{3} - 15\sqrt{2} + 9\sqrt{6}$$

and $\cot\frac{\theta}{2} = \sqrt{r^2-1} = \sqrt{25-13\sqrt{3} -15\sqrt{2}+9\sqrt{6}}=1.82086.$

Solution by Charles W. Trigg, San Diego, California.

Using the notation of the preceding solution, DM is the perpendicular bisector of BC and bisects $\angle$ BDC. Draw DE where E is the midpoint of AB and DE is the perpendicular bisector of AB and the bisector of $\angle$ ADB. Hence BM = 1, BD = r, BE = 3/2, 1/2 $\angle$ BDC = $\angle$BDM = θ and $\angle$BDE = 75° - θ. In right triangles BDF and BDE, $\sin\theta = 1/r$ and $\sin(75^\circ - \theta) = 3/2r$.

Eliminating r:

$3 \sin \Theta = 2 \sin(75^\circ - \Theta) = 2(\sin 75^\circ \cos\Theta - \cos 75^\circ \sin\Theta)$

so $(3+2 \cos 75^\circ) \sin \Theta = 2 \sin 75^\circ \cos \Theta$.

Then $\cot \Theta = \dfrac{\cos \Theta}{\sin \Theta} = \dfrac{3+2 \cos 75^\circ}{2 \sin 75^\circ}$.

Writing $75^\circ = 30^\circ + 45^\circ$ and expanding we obtain

$$\cot \Theta = \frac{3+(\sqrt{3} - 1)(1/\sqrt{2})}{(1+\sqrt{3})(1/\sqrt{2})} = \frac{3\sqrt{2} + \sqrt{3} - 1}{\sqrt{3} + 1}$$

$$= \frac{3(\sqrt{6} - \sqrt{2})}{2} + 2 - \sqrt{3} = 1.8206.$$

Also solved by Kenneth Michael Gustin, Lansdale, Pennsylvania, Robert A. Stump, Hopewell, Virginia, Simon Gin Jowki, Edmonton Alberta, Canada, and the proposer.

Editor's comment: The proposer submitted the following figure which allows direct determination of the necessary trigonometric values.

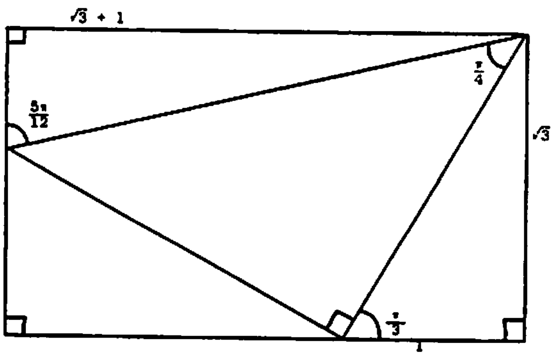


Figure 2

318. Proposed by Charles W. Trigg, San Diego, California.

The series of positive integers is divided into the groups (1); (2,3,4,5); (6,7,8,9,10,11,12); (13,14,15,16,17,18,19,20,21,22); . . . .Find the sum of the integers in the nth group.

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

There are 3n - 2 positive integers in the nth group. The smallest integer in the nth group is

$$\sum_{k=1}^{n-1} (3k - 2) + 1 = \frac{1}{2}(3n^2 - 7n + 6)$$

while the largest integer in the nth group is

$$\frac{1}{2}(3n^2 - 7n + 6) + 3n - 3 = \frac{1}{2}(3n^2 - n).$$

Finally, since the nth group forms an arithmetic progression, the sum of the nth group is given by

$$\frac{(3n - 2)(a_1 + a_N)}{2} \quad \text{where} \quad a_1 = \frac{1}{2}(3n^2 - 7n + 6)$$

and $a_N = \frac{1}{2}(3n^2 - n)$. The desired sum is

$$\frac{1}{2}(3n - 2)(3n^2 - 4n + 3).$$

Solution by David K. Yee, Hawthorne, California.

Since the nth group contains 3n-2 integers, the last integer in the nth group is

$$\sum_{i=1}^{3n-2} i = \frac{3n^2-n}{2} .$$

The sum of the integers in the nth group is

$$\sum_{i=1}^{\frac{3n^2-n}{2}} i \quad - \quad \sum_{i=1}^{\frac{3(n-1)^2-(n-1)}{2}} i$$

$$= \frac{(3n^2-n)(3n^2-n+2)}{8} - \frac{(3n^2-7n+4)(3n^2-7n+6)}{8}$$

$$= \frac{9n^3-18n^2+17n-6}{2} = \frac{(3n-2)(3n^2-4n+3)}{2} .$$

Also solved by Kenneth Michael Gustin, Lansdale, Pennsylvania; Fred A. Miller, Elkins, West Virginia; Robert A. Stump, Hopewell, Virginia; and the proposer (two solutions).

319. *Proposed by Charles W. Trigg, San Diego, California.*

Use the basic nine-digit third order magic square to generate eight other third order magic squares that have a common magic constant. Each new square is to have nine distinct elements, and at least three elements are to be prime in five of the new squares.

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

The basic nine-digit third order magic square is

8	1	6
3	5	7
4	9	2

We shall use this magic square to generate eight new magic squares each having a magic constant of 135. (For third order magic squares it is known that the entry in the middle cell must be 1/3 of the magic constant so in each of our eight squares the middle entry will be 45.). The notation ak + b under each square indicates that each entry in the basic square was multiplied by a and then added to b to produce the corresponding entry in the new magic square. An asterisk following an element indicates that it is a prime number.

48	41*	46
43*	45	47
44	49	42

k + 40

51	37*	47*
41*	45	49
43*	53*	39

2k + 35

54	33	48
39	45	51
42	57	36

3k + 30

57	29*	49
37*	45	53*
41*	61*	33

4k + 25

60	25	50
35	45	55
40	65	30

5k + 20

63	21	51
33	45	57
39	69	27

6k + 15

66	17*	52	69	13*	53*
31*	45	59*	29*	45	61*
38	73*	24	37*	77	21

<u>7k + 10</u> <u>8k + 5</u>

Also solved by Robert A. Stump, Hopewell, Virginia, and the proposer.

320. *Proposed by Michael W. Ecker, Pennsylvania State University/Worthington Scranton Campus, Scranton, Pennsylvania.*

Define a permuted repunit pair (PRP) to be a pair of positive integers x,y with x > y such that

(a) the decimal digits of x and y are permutations of one another; and

(b) x+y = a repunit (i.e., a decimal integer consisting solely of ones such as 111111).

If n is the number of ones in a given repunit, for which values of n do corresponding PRP's exist?

For a given integer n for which PRP's exist, find the PRP (x,y) such that the product xy is a maximum.

Composite of solutions submitted by Robert A. Stump, Hopewell, Virginia, and the proposer.

Since the decimal digits of x and y are permutations of one another, each of x and y are greater than 10. Suppose x = 10t+u and y = 10u+t for integers t and u. Then $11|(x+y)$ and $11\nmid 111$. Hence there are no PRP's for $n \leq 3$.

For $n \geq 4$ let $x + y = R_n$ where R_n denotes the number consisting of n 1's. Since

$xy = (\frac{x+y}{2})^2 - (\frac{x-y}{2})^2$ is maximized when x-y is made as small as possible, take $x-y = 1$ so that

$$x = \frac{R_n+1}{2} = \underbrace{55 \ldots 5}_{n-2}6 \quad \text{and} \quad y = \frac{R_n-1}{2} = \underbrace{55 \ldots 5}_{n-1}$$

While x and y maximize the product xy, they do not form a PRP. Construct two new numbers $Y = x - 50$ and $X = y + 50$. Then X and Y form a PRP and maximize the product XY at the same time.

$$Y = \underbrace{555 \ldots 5}_{n-3}06 \quad \text{and} \quad X = \underbrace{555 \ldots 5}_{n-4}605$$

That (X,Y) form the desired solution follows from the fact that the right most digits in X and Y must have a sum of 11 and a difference as small as possible.

321. *Proposed by Fred A. Miller, Elkins, West Virginia.*

In a circle whose center is at O, radii OA and OB are drawn. Construct a chord which will be trisected by radii OA and OB.

Solution by Robert A. Stump, Hopewell, Virginia.

Given the circle whose center is at O and radii

OA and OB, draw chord AB. Extend chord AB to points X and Y such that XA = AB = BY. Draw OX and OY. Let R and S denote the points of intersection of the circle and lines OX and OY respectively. Then RS is the desired chord.

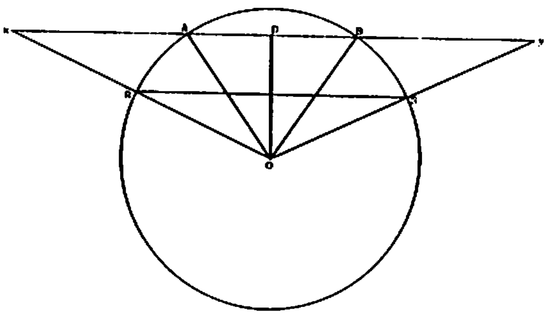


Figure 3

Proof: Draw AD where D is the midpoint of chord AB. Then AD ⊥ AB and triangles ADO and XDO are congruent to triangles BDO and YDO respectively. Then OX = OY and XR = SY so that XY||RS. Finally triangles ORS and OXY are similar. Hence XA = AB = BY implies that chord RS is trisected by the radii OA and OB.

Also solved by the proposer. One incomplete solution was received which established sufficient conditions for the construction to occur, but it failed to give a construction as required by the statement of the problem.

Editor's comment: Late solutions to problems 314 and 315 were received from Simon Gin Jowki of Edmonton Alberta, Canada.

THE MATHEMATICAL SCRAPBOOK

EDITED BY RICHARD LEE BARLOW

Readers are encouraged to submit Scrapbook material directly to the Scrapbook editor. Material will be used when possible and acknowledgment will be made in THE PENTAGON. Please send material to the Scrapbook editor: Dr. Richard Barlow, Department of Mathematics, Statistics and Computer Science, Kearney State College, Kearney, NE 68847.

In recent years, computer generated random numbers have been extensively used by mathematicians and statisticians to simulate models. Much research in statistical and mathematical modeling resorts to a table of computer generated random numbers. It is usually automatically assumed that the random numbers are indeed random without verification. However, if one wishes to examine the randomness of the table, a Chi-square Test is usually used to verify the table.

Random numbers can be generated assuming uniform, normal, etc., distributions for the ten individual digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. In this presentation, we shall assume a uniform distribution for the digits; that is, we shall assume each of the ten digits appears 10% of the time in the random number table. One must be careful not to make the mistake that in a small number of digits, like ten or twenty, we must have 10% of each digit. Instead, the theoretical 10% applies to the complete population and usually approximately applies only for extremely large samples (say 1000 digits or more).

A statistical distribution studied in elementary mathematical probability is the Poisson Distribution. The Poisson Distribution applies to such diverse situations as the arrival time of customers to a supermarket checkout line, the number of defects in a manufactured product, the number of traffic accidents on a particular street, etc., where it is assumed that the occurrence of the events do not influence each other.

The discrete Poisson model has a probability mass function of

$$P(x) = e^{-\lambda} \cdot \frac{\lambda^x}{x!}, \text{ for } x = 0, 1, 2, 3, 4, \ldots,$$

where x is the number of events occurring in a unit of time and $\lambda = E(x)$; that is, λ represents the mean number of occurrences of the event in a unit of time.

Suppose one wishes to simulate a model where the probability of the event occurring is .10. One could use the random number table (or have a computer simulate one), with the occurrence of any one previously specified digit as representing the occurrence of the event. If any of the other nine digits occurs, the event has not occurred. Using this rule, the event should (in theory) occur 10% of the time if the random numbers are uniformly produced as expected.

Suppose now that we let the occurrence of the digit "2" represent the occurrence of the event. Then if any of the other nine digits occurs, we will take this as the non-occurrence of the event. We can consider this to be a Poisson model with a unit length of, say, ten digits. Hence, $\lambda = (10)\cdot(.10) = 1 = E(x)$, where $x = 0, 1, 2, \ldots, 10$. (Note that x is a Binomial random variable where x represents the number of "2's" occurring in our unit length of ten digits.) Hence the Poisson probability mass function is

$$P(x) = e^{-1}\frac{1^x}{x!} = \frac{1}{ex!}\ , \text{ for } x = 0, 1, 2, \ldots, 10.$$

Using the above Poisson probability mass function to compute P(x), we obtain Table 1, where x equals the number of occurrences of the event in a unit length.

Table 1

x	P(x)
0	.3679
1	.3679
2	.1839
3	.0613
4	.0153
5	.0031
6	.0005
7	.0001
8	.0000
9	.0000
10	.0000

The table indicated that 0 or 1 occurrences of the event are each expected approximately 36.79% of the time and are most likely. One will note that it is very unlikely to have the event occur more than three times in a unit interval.

Let us now examine unit lengths (of ten digits) from a random number table such as Table J from Table XXXIII found in _Statistical Tables for Biological, Agricultural and Medical Research_ by Fisher and Yates. Randomly entering the table and proceeding down the columns, one obtains the following table.

Table 2

Random Digits (unit length)					Number 2's
73	43	07	34	48	0
48	62	11	90	60	1
28	97	85	58	99	1
02	63	45	52	38	2
76	96	59	38	72	1
77	45	85	50	51	0
29	18	94	57	23	2
72	65	71	08	86	1
89	37	20	70	01	1
81	30	15	39	14	0
83	71	46	30	49	0
70	52	85	01	50	1
25	27	99	41	28	3
63	61	62	42	29	3
68	96	83	23	56	1
87	83	07	55	07	0
49	52	83	51	14	1
80	62	80	03	42	2
86	97	37	44	22	2
85	39	52	85	13	1

Table 2 (Continued)

Random Digits (unit length)					Number 2's
97	05	31	03	61	0
75	89	11	47	11	0
09	18	94	06	19	0
84	08	31	55	58	0
79	26	88	86	30	1
01	61	16	96	94	0
46	68	05	14	82	1
00	57	25	60	59	1
24	98	65	63	21	2
28	10	99	00	27	2

The Relative frequency distribution for the first 10, 20 and 30 unit lengths is as follows:

Table 3

Number 2's	Relative Frequency		
x	In First 10 Units	In First 20 Units	In All 30 Units
0	.30	.25	.33
1	.50	.45	.40
2	.20	.20	.20
3	.00	.10	.07
4	.00	.00	.00
5	.00	.00	.00
6	.00	.00	.00
7	.00	.00	.00
8	.00	.00	.00
9	.00	.00	.00
10	.00	.00	.00

The above table tends to indicate that by increasing the number of unit intervals one obtains results closer to the Poisson Probabilities listed in Table 1. In fact, the relative frequencies listed for all 30 unit intervals are very close to the expected percentages in Table 1. Hence the above simulation of an event (using the occurrence of the random digit "2" to represent the occurrence of the event) appears to be a good model simulation using a Poisson model.

An obvious question which deserves possible consideration would be: "Is the model simulation equally good if one were to use the occurrence of some other random digit (such as a 3 or 7) to represent the occurrence of the event?" Can you determine this?

THE HEXAGON

EDITED BY IRAJ KALANTARI

This department of THE PENTAGON is intended to be a forum in which mathematical *issues* of interest to undergraduate students are discussed in length. Here by *issue* we mean the most general interpretation. Examination of books, puzzles, paradoxes and special problems,(all old or new) are examples. The plan is to examine only one issue each time. The hope is that the discussions would not be too technical and be entertaining. The readers are encouraged to write responses to the discussion and submit it to the editor of this department for inclusion in the next issue. The readers are also most encouraged to submit an essay on their own issue of interest for publication in THE HEXAGON department. Address all correspondence to *Iraj Kalantari, Mathematics Department, Western Illinois University, Macomb, Illinois 61455.*

Contributed by G. W.

The following correspondence has been brought to the editor's attention.

Dear Iratnalak:

In browsing through my grandfather's memorabilia, I came across the enclosed fragment of a manuscript. As you know my grandfather was an ever faithful friend of the Sherlock Holmes and was in the habit of chronicling his cases. I found this particular record quite disturbing and because of its opaque logic, I thought it may be of mathematical interest. I send it to you in the hope that as a mathematician you may find it amusing if not transparent.

Love always,

Gloria Watson

The manuscript reads:

...

It was 5 days before the New Year when Holmes and I returned to London after closing the abyssinian case once and for all. Upon entering our flat on Baker

Street, Holmes immediately detected something amiss. He silenced me with a quick glare and drew an envelope from within the recesses of my old medical bag. It was a message - and it was signed Moriarty!

'But how, Holmes?'

'Quiet, Watson, I must think.'

Holmes paced the room twice and thrust the fiendish message into my palm.

'Read that, my dear fellow! Read that!'

The note had the faint odor of tobacco,which I remarked to Holmes as I began to read its unnerving contents:

Your fate is sealed, Sherlock Holmes. Death will claim you before the year is gone. The time will be sunset but even you will not know the day. Good bye, dear Holmes - it was fun, I'm sure.

Moriarty

Holmes was closing the window against the evening chill as I looked up with Moriarty's name still on my lips. He could barely contain his excitement as he turned this new puzzle over in his mind.

'I will certainly not die on the 31st, Watson! he blurted defiantly.

'What?'

'The 31st, Watson, don't you see? If I'm still alive past sunset on the 30th, then I will know the 31st is the day Moriarty has set since he intends for my demise to precede the New Year. But I am not to know, Watson, I am not to know.'

I was amazed by his dazzling mind as I always shall be. It was true. If Moriarty waited til the last day of the year to carry out his deed, then certainly we shall know the evening before and thereby ruin the evil prediction. It would not be like Moriarty to be wrong in such a thing. So the 31st was not the day. Holmes continued with hesitation...

'And if not the 31st, Watson, then not the 30th.'

'What?'

'If I survive the sunset on the 29th I will immediately know I am to die on the 30th or on the 31st, but the 31st is already ruled out. The 30th would be left and I will know the 30th is the day of my reckoning. But, Watson, I am not to know the day - not to know. But if he waits til the 30th I will know. So it is not the 30th.'

True it was, or so it seemed to me. Holmes, if he is not to know the day of his murder, must meet his end before the 31st. So the 30th is the last possible day for the appointed deed. But if it's carried out on the thirtieth, then Holmes will still be alive on the eve of the 29th. He will then know the last day, the 30th, is the scheduled day...which is contrary to the prediction of his not knowing.

'Holmes,' I suggested, 'then it is not the 29th either.'

'You were always quick to spy a pattern, Watson. The fact is, it cannot be any day this week from now til New Years. By this logic I cannot be killed.'

'Somehow, Holmes, I am not relieved.'

'Neither am I, Watson, neither am I.'

The room was silent as Holmes stuffed his favorite Calabash. I watched the yellow stained fingers deftly apply a match to the bowl, and wondered as to the meaning of Moriarty's labyrinthian note. I fought my way twice thru the deductions concluding each time that Holmes could not be killed on any day from now til New Years. Yet the note said he will be killed before the year is gone. The note seemed contradictory - 'and yet,' I thought, if he were killed tomorrow the prediction would be entirely true.' A contradictory prediction which could become true was more than I cared to fathom.

'That's it, Watson. You've got it,' Holmes interrupted the silence. But it is not the message that is contradictory.

'How did you --?'

'That's unimportant, Watson. What is important is that no man's behavior, not even Moriarty's, is reliable.'

'What?'

'Think man! We've been duped. The message itself is not contradictory. It may even be true as you're thinking. But, the message together with the assumption that it is true and its contents now known to us, leads to a contradiction. Thus we cannot know the message is true. It may be, (knowing Moriarty, it likely is) and it may not be true. We cannot know, about that Moriarty is right. 'Indeed,' Holmes concluded, 'we should not even be surprised as it is my belief that no one's word is reliable. Even if you told the truth all of the time, Watson, how should I know it?'

With the puzzle solved, Holmes sank into a melancholy boredom, slouching into his chair with the smoke from his calabash twisting its way to the ceiling. I was not at all ready to close the matter, as I sat opposite Holmes and began to unravel the logic once more.

End of manuscript

Dearest Gloria,

I was returning home tonight from a typically formal good bye party for our mutual friend Dr. Eniuq who is on his way to Greece, when my butler presented your letter to me with my bedtime ration of soda water. It is jolly good of you to write.

I think your newly discovered manuscript is simply marvelous. However, as I began to pursue the enchanting dialogue between Holmes and Watson, while walking upstairs to my personal quarters, I was unable to avoid this curious sense of deja vu. For a moment I thought that perhaps I have already come upon this document while inspecting the dusty shelves of the personal library of Sir Rendrag Nitram.

It was not too long however, before I realized I have only read something similar to it. "Good heavens ..." I sighed with relief that your discovery is not in vain. "Where? ..., where have I seen this before?" I repeated to myself as I began to loosen my tie. It was quite late in the evening and I was alone and had reached the privacy of my bedroom, so I thought disrobing was proper. It suddenly came to me in an extraordinary way. My tie, quite unsportingly, began to choke me instead in a quite discomforting manner. I was then reminded of the time that I was almost hanged by those Amazon women during the 1948 expedition we undertook together. As I finally removed the tie and sat on the bed gasping for air, I made a connection. "Hanged by the Amazon women, ... a surprise, ... unexpected, ... 'The Unexpected Hanging'!!". It all came to me in a flash. I knew where I had seen the similar version. I dashed downstairs to my study with such a rush that neither did I wear my tie back nor did I put on my robe; most silly. Once in the study,I discovered, on the upper right shelf, the book I was looking for:

"The Unexpected Hanging" - by Martin Gardner.

Extraordinarily, I opened the book to the correct page and found a puzzle which is curiously similar to the content of your discovery. Allow me to quote for you from Gardner's book, page 11:

> ...The paradox was first circulated by word of mouth in the early 1940's. It often took the form of a puzzle about a man condemned to be hanged.
>
> The man was sentenced on Saturday. "The hanging will take place at noon," said the judge to the prisoner. "On one of the seven days of next week. But you will not know which day it is until you are so informed on the morning of the day of the hanging.
>
> The judge was known to be a man who always kept his word, The prisoner, accompanied by his lawyer, went back to his cell. As soon as the two men were alone the lawyer broke into a grin. "Don't you see?" he exclaimed.

"The judge's sentence cannot possibly be carried out.

"I don't see," said the prisoner.

"Let me explain. They obviously can't hang you next Saturday. Saturday is the last day of the week. On Friday afternoon you would still be alive and you would know with absolute certainty that the hanging would be on Saturday. You would know before you were told so on Saturday morning. That would violate the judge's decree."

"True," said the prisoner.

"Saturday,then is positively ruled out," continued the lawyer. "This leaves Friday as the last day they can hang you. But they can't hang you on Friday because by Thursday afternoon only two days would remain: Friday and Saturday. Since Saturday is not a possible day, the hanging would have to be on Friday. Your knowledge of that fact would violate the judge's decree again. So Friday is out. This leaves Thursday as the last possible day. But Thursday is out because if you're alive Wednesday afternoon, you'll know that Thursday is to be the day."

"I get it," said the prisoner, who was beginning to feel much better. "In exactly the same way I can rule out Wednesday, Tuesday, and Monday. That leaves only tomorrow. But they can't hang me tomorrow because I know it today!"

In brief, the judge's decree seems to be self-refuting. There is nothing logically contradictory in the two statements that make up his decree; nevertheless, it cannot be carried out in practice.

Later, on page 19, Gardner offers a resolution:

> The judge speaks truly and the condemned man reasons falsely. The very first step in his chain of reasoning - that he cannot be hanged on the last day - is faulty. Even on the evening of the next-to-last day, ...-he has no basis for a deduction. This is the main point of Quine's 1953 paper. In Quine's closing words, the condemned man should reason: "We must distinguish four cases: first, that I shall be hanged tomorrow noon and I know it now (but I do not); second, that I shall be unhanged tomorrow noon and know it now (but I do not); third, that I shall be unhanged tomorrow noon and do not know it now; and fourth, that I shall be hanged tomorrow noon and do not know it now. The latter two alternatives are the open possibilities, and the last of all would fulfill the decree. Rather than charging the judge with self-contradiction, therefore, let me suspend judgment and hope for the best."

Although I should like you to examine Gardner's delightful book for many interesting discussions, I thought about the matter for some time and have formulated what follows.

You see, a *paradox* arises when there has been an attempt to put into logical form, explanation of some phenomenon or experiment. When the ramifications of this attempt are not in total compliance with our logical experiences, we cry Paradox! But this paradox could be one of the two forms: *apparent* or *real*. An apparent paradox is one which arises because we have performed some logically improper operation (such as division by zero). A real paradox arises when some intuitive notion of the said phenomenon, which was hoped to have been captured by logical formalism, contradicts our known logic.

The resolution in the case of an apparent paradox is to discover the improper operation and avoid it. The resolution in the case of a real paradox is to resign from the claim that our present logic is so rich that it can capture any intuitive notion, and that our assumptions are actually true.

In the case of the judge and the unfortunate prisoner, we note that the crux of the matter of the paradox is on the notion of "to know". It is what the prisoner *knows* that we are attempting to formalize. If we consider the prisoner's *knowledge* after the judge's statements, we note that he thinks

> *1) I am to know that I will be hanged some day next week.*
>
> *2) I am to know that I am not to know the exact day of the hanging until I am so informed.*

From 2), the prisoner then concludes

> *3) I am to know that if the last day of the week is the hanging day, then I am not to know it.*

But he also concludes (by common sense) that

> *4) I am to know that if the last day of the week is the hanging day then I am to know it (because I would be still alive!)*

From 3) and 4) the prisoner deduces that

> *5) I am to know that if the last day of the week is the hanging day, then I am to know it <u>and</u> I am not to know it.*

At this stage, if by "know" we mean "to have a proof of", the prisoner could proceed to eliminate the last day as a possibility and continue to eliminate all of the days as a possible hanging day all under the belief that his original assumptions are indeed true. Then he is hanged on Wednesday and is surprised by a paradox not to mention the rope! In this case, there is an apparent paradox whose resolution lies in the point that he should either not interpret "to know" as "to have a proof of" or not assume that the judge's fame for consistency as a proof of his statements.

More generally, if the prisoner should interpret "to know" intuitively but strongly enough so that from 5) he could eliminate the last day, he could continue the argument as before and arrive at a paradox.At that stage, he has two choices:

a) "to know"is not to be interpreted as strongly as it has been to allow us to draw conclusions from the knowing what the judge said.

b) my interpretation of "to know", my assumptions and my logic are not compatible. And since my interpretation of "to know" and my logic are agreed to be sound, it must be my assumptions which are paradoxical.

In case a) we have an apparent paradox,while in case b) we have a real paradox. It is the case b) that Holmes and Watson follow in your manuscript. The prisoner, upon further examination, could conclude that the flaw in his argument is in the assumption that the judge's words constitute knowledge. Even if the judge would keep his word, the assumption that the words are true, together with the interpretation of its' content and our conventional logic leads to a stalemate.

Oh my dear Gloria, it is almost dawn and I have a polo match tomorrow, so I must push off. I urge you to look up Gardner's book, I am sure you will like it. Please give my regards to Lady Cigol and do write again and tell me what you think; I am most curious.

Cheerio,

Iratnalak Jari

KAPPA MU EPSILON NEWS

EDITED BY HAROLD L. THOMAS, HISTORIAN

News of chapter activities and other noteworthy KME events should be sent to Dr. Harold L. Thomas, Historian, Kappa Mu Epsilon, Mathematics Department, Pittsburg State University, Pittsburg, Kansas 66762.

REPORT ON THE 1980 REGION I CONVENTION

PA Iota hosted the Region I meeting at Shippensburg State College in Shippensburg, PA on 11, 12 April 1980. Dr. John Mowbray, corresponding secretary, and Nelson Fernandez, president, coordinated the program. Twenty students and ten faculty members from four chapters were represented at the meeting--MD Beta, PA Theta, PA Lambda, and PA Iota. Friday evening activities began with hospitality hour and registration. This was followed with a buffet style banquet which was excellent and well attended. Dr. James E. Lightner, National President, KME, gave the banquet talk, "Mathematicians Are Human Too--And Not Always Serious."

Saturday morning following registration and coffee, nine students presented papers competing for prizes of $40, $30, and $20. David Scicchitano, PA Theta, Susquehanna University, took first place with his paper, "The Quantum Mechanical Solution of the Hydrogen Atom: A Study in Applied Differential Equations." Second place went to Louise Kurtz, PA Lambda, Bloomsburg State College, for her presentation on "Rotors." William Link, MD Beta, Western Maryland College received third place for his paper, "Life or Death"? Will the Gambler Ever Get Out of Atlantic City?" Other papers given included: "LaPlace Transform as a Means for Obtaining the Steady State Solution of the High Pass, Low Pass, and Twin Capacitance-Resistance "T" Filter Networks" by Dwight Gordon, PA Theta, Susquehanna University; "An Error Correcting Code," by Cathy Folk, PA Lambda, Bloomsburg State College; "A Dielectric Sphere in a Uniform Electric Field," by Robert Pickart, PA Theta, Susquehanna University; "On Not Computerizing Games," by Gregory J. Goodhart, PA Iota, Shippensburg State College; "Potential from Poisson's Equation,"by Douglas Garman, PA Theta, Susquehanna University; and "Public Key Cryptography," by Kim Hellerman, PA Lambda, Bloomsburg State College.

Following the student papers the participants saw a demonstration of the Raytheon PTS/1200 Hands-on-Computer. Then Dr. Howard Bell, Shippensburg State College gave an address "How to Catch Lions in the Sahara Desert."

Awards were presented at the Saturday luncheon by Dr. Lightner. The chapters are already making plans for the 1982 Region I convention.

REPORT ON THE 1980 REGION IV CONVENTION

Ten Region IV chapters were present with approximately eighty-five students and faculty in attendance at the regional convention hosted by IL Eta at Western Illinois University in Macomb, IL on 11, 12 April 1980. Chapters represented included IL Eta, IA Alpha, KS Alpha, KS Beta, KS Delta, MO Beta, MO Eta, MO Theta, MO Iota, and NB Alpha.

IL Eta officers, Deborah Oganovich, president, Mary Cannon, vice president, and Susan Dufek, secretary-treasurer, coordinated the meeting. They were assisted by Dr. Paul Humke, Dr. Larry Morley, corresponding secretary, and Dr. Kent Harris, PENTAGON editor.

Friday evening activities consisted of a Math Mixer in Tanner Hall Lounge. Following registration, coffee, and donuts Saturday morning, Dr. Daryl Kreiling, College of Arts and Sciences Dean, welcomed the group to the campus.

Seven students from Region IV chapters then competed for four awards given for paper presentations. Plaques were given for the awards. Susan Dufek, IL Eta secretary-treasurer presided at the morning and afternoon paper sessions.

Deborah Oganovich, IL Eta, Western Illinois University took first place with her paper, "The Plowshare Problem." Second place went to Randal Leimer, KS Delta, Washburn University for his presentation, "Graph Theory in Decision Making." Michael Fallin, MO Beta, Central Missouri State University, was awarded third place for "Pyramid Expansion." Fourth place plaque went to Jill Roesch, IA Alpha, University of Northern Iowa, for her paper, "The Orchard Problem." Other papers given included: "Curves: What Are They," by Virginia Chizek, IA Alpha, University of Northern Iowa; "The Compass by Itself," by Kyle Stravers, IA Alpha, University of

Northern Iowa; "Perfect Numbers," by Jo Ann Vannini, IA Alpha, University of Northern Iowa.

Faculty members from the Western Illinois University's mathematics department presented a special panel discussion following the student papers. Their topic was "Where Do We Go From Here," or "What's There for a Math Student after College." The convention concluded with a banquet Saturday evening. The banquet address was given by Dr. Joe Stipanowich from Western Illinois University's mathematics department. His very enjoyable talk was entitled "The Mathematician's Waltz." Entertainment was then provided by the rock band "A Fresh Start."

Region IV chapters are now making plans to attend the Twenty-third Biennial Convention at Springfield, Missouri in the spring of 1981.

CHAPTER NEWS

Alabama Gamma, University of Montevallo, Montevallo
Chapter President-James A. Richey
19 actives

The chapter held several meetings throughout the semester and initiated eleven new members. A "CRC Book of Standard Mathematics Tables" was presented to the outstanding freshman mathematics student. Other 1980-81 officers: Danny Blackerby, vice president; Melody Acker, secretary; Charlene Garrett, treasurer; Joseph Cardone, corresponding secretary; Angela Hernandez, faculty sponsor.

California Gamma, California Polytechnic State University, San Luis Obispo
Chapter President-Christi Strain
45 actives, 29 pledges

The chapter held a Math Field Day for all junior high school students in the county. The chapter assisted the Mathematics Department faculty with Poly Royal (annual open house), including a mathematics contest which attracted over 500 high school students. Chapter meetings included alumni speakers and industry representatives. An annual Math Sciences Career Day was sponsored by the chapter. It included speakers from business and industry. The annual initiation banquet included about 90 members and guests.

Other 1980-81 officers: Phil Diaz and Lori Canter, vice president; Leigh Cheek, secretary; Lisa Beverly, treasurer; George R. Mach, corresponding secretary; Adelaide Harmon-Elliott, faculty sponsor.

Colorado Beta, Colorado School of Mines, Golden
Chapter President-Shelby Switzer
15 actives

Dr. R. S. McKnight, manager of Geophysical Research at Marathon Oil Company, made a special presentation to the chapter highlighting the role of the mathematician in petroleum research and fundamentals of seismic date processing. Other 1980-81 officers: Preston Wallace, vice president; John Henderson, secretary; Russ Kemp, treasurer; Ardel Boes, corresponding secretary; Robert Underwood, faculty sponsor.

Georgia Alpha, West Georgia College, Carrollton
Chapter President, Lisa Yates
21 actives, 3 pledges

Three new members were initiated on May 13, 1980. The new members were honored with a reception after the business meeting at which time new officers were elected. The KME pledges were further honored at the college-wide annual Honors luncheon. As a part of the 1979-80 mathematics lecture series, Mrs. Sally Robinson of the mathematics department, gave a talk "Structured Programming-Background and Methods." Several KME members attended. Other 1980-81 officers: Patricia Ingram, vice president; Annelle Colevins, secretary; Donald Summers, treasurer; Thomas J. Sharp, corresponding secretary and faculty sponsor.

Illinois Beta, Eastern Illinois University, Charleston
Chapter President-Jeff Bivin
49 actives, 14 pledges

Other officers for 1980-81: Jim O'Dell, vice president; Jane Fischer, secretary; Peggy Hall, treasurer; Patricia Ryan, corresponding secretary; J. Nanda, faculty sponsor.

Illinois Zeta, Rosary College, River Forest
Chapter President-Sharon Holder
10 actives, 8 pledges

Members of the Illinois Zeta chapter puzzled over sailors, coconuts and remainders of various sorts at their meetings this semester. Eight new members were initiated on March 26, 1980 after which 1977 graduate Tom Kourim, a programming applications director and master's candidate at Illinois Institute of Technology, spoke to the group on computers. Other 1980-81 officers: Karen Kmiecik, vice president;Mary Locascio, secretary; Sister Nona Mary Allard, corresponding secretary and faculty sponsor.

Illinois Eta, Western Illinois University, Macomb
Chapter President-Douglas Sorensen
8 actives, 10 pledges

The major spring activity for the chapter was hosting the Region IV convention of KME. A report on the convention is included in this issue. Other 1980-81 officers: Mary Cannon, vice president; Margaret Juraco, secretary-treasurer; Larry Morley, corresponding secretary; Iraj Kalantari, faculty sponsor.

Illinois Theta, Illinois Benedictine College, Lisle
Chapter President-Chung-Cheng Tai
25 actives, 20 pledges

During the spring semester the chapter invited an alumnae to speak on work she had done on a Rotary scholarship in England last year. The induction ceremony was held on Friday, April 11, in the early evening and followed by a reception for students, faculty and friends. The Dean of Faculty, Dr. Marvin E. Camburn spoke on the topic:"For the Honor of the Human Spirit." Twenty new members were inducted including one faculty member, three alumni and 16 students. A party,hosted by one of the members was held on May 24th. Other 1980-81 officers: Martin Johnson, vice president; Susan Milnanow, secretary; Peter Ruocco, treasurer; Phyllis Kittel, corresponding secretary and faculty sponsor.

Indiana Alpha, Manchester College, North Manchester
Chapter President-Pat McQuillian
16 actives, 13 pledges

The highlight of the semester was the annual spring banquet with induction of new members. Guest speaker was Dr. David L. Newhouser of Taylor University, whose topic was "Mathematics in Literature." Other 1980-81 officers: Craig Stine, vice president; Ramona Seese, secretary; Steve Stichter, treasurer; Ralph McBride, corresponding secretary and faculty sponsor.

Indiana Delta, University of Evansville, Evansville
Chapter President-Mark Simpson
39 actives, 17 pledges

Spring semester programs included: "Applications of Psychology and Mathematics"by Dr. Lakey;"Coding Theory" by Dr. Tooley;"Everything you ever wanted to know about 878 pieces of cardboard and 1768 rubber bands but were afraid to ask," by Dr. Broline. Other 1980-81 officers: George Brunemann, vice president; Debra Goedde, secretary;Mrs. Melba Patberg, corresponding secretary; Duane Broline, faculty sponsor.

Iowa Alpha, University of Northern Iowa, Cedar Falls
Chapter President-JoAnn Vannini
33 actives

The semester began with a pizza party at Happy Joes in late January. KME invited the members of the other five honor societies in the College of Natural Sciences to participate--Dutch treat. The following students presented papers at meetings during the spring semester 1980: Brenda Walker on "The Prismoidal Formula," Kaley VanDeventer on "Computers and Crime," and new initiate Kay Sacquitne on "Old MacDonald has a Computer," at the initiation banquet. Each of the four students who attended the KME Region IV convention at Western Illinois University April 11-12 presented a paper there: Virginia Chizek on "Curves: What are They," Kyle Stravers on "The Compass by Itself," JoAnn Vannini on "Perfect Numbers," and Jill Roesch on "The Orchard Problem." Ms. Roesch was awarded a plaque for fourth place. The KME-math faculty picnic was held the first Sunday in May with Professor Wehner once again burning the hot dogs to perfection. Other 1980-81 officers: Virginia Chizek, vice president;Kay Sacquitne, secretary; John Christensen, treasurer; John S. Cross, corresponding secretary and faculty sponsor.

Iowa Delta, Wartburg College, Waverly
Chapter President-Tim Alpers
33 actives

The annual banquet and initiation of members was held March 22, 1980. At that time six students were initiated. Other 1980-81 officers: Tami Worby, vice president;

Karen Waltmann, secretary; Ed Lee, treasurer; Lynn J. Olson, corresponding secretary and faculty sponsor.

Kansas Alpha, Pittsburg State University, Pittsburg
Chapter President-Brenda Brinkmeyer
40 actives

Kansas Alpha started the spring semester with a banquet and initiation for the February meeting. Fifteen new members were initiated at that time. Doug Johnston presented the program on mathematical games. The March program was presented by Nancy Tanner on "Biorythms and the Sine Curve." Kevin Sperry gave the April program. His topic was "Data Base Relational Model." The chapter also assisted the mathematics department faculty in administering and grading tests given at the annual Math Relays,April 29,1980. Four members attended the regional convention hosted by IL ETA at Macomb, Illinois. The final meeting of the spring semester was held at Professor Sperry's home. It was highlighted by election of officers for the 1980-81 school year. In addition, the annual Robert M. Mendenhall award for scholastic achievement was presented by Kay Conklin. She received a KME pin in recognition of this honor. Other 1980-81 officers: Linda McCracken, vice president; Irma Reasoner, secretary; Donna Pintar, treasurer; Harold L. Thomas, corresponding secretary; J.Bryan Sperry,faculty sponsor.

Kansas Beta, Emporia State University, Emporia
Chapter President-Carol Whitney
24 actives, 9 pledges

The chapter was very active this past semester. Programs were given by both students and faculty on mathematical topics. In addition, one program consisted of the findings of a faculty committee on the best study habits students employ as well as data on how many students use them. Seven members attended the Region IV convention at Macomb, Illinois. The annual spring picnic was enjoyed by a large turnout of students and faculty. Other 1980-81 officers: Mike Briggs, vice-president;DeAnna Koch,secretary;Rose Herman, treasurer; John Gerriets, corresponding secretary; Thomas Bonner, faculty sponsor.

Kansas Gamma, Benedictine College, Atchison
Chapter President-Leo Vitt
26 actives, 8 associate members

The 40th anniversary of the founding of KS Gamma was celebrated by some 60 persons on 9 March. In attendance were 29 KS Gamma alums, five of whom were charter members. After a slide presentation on the history of the chapter by Sister JoAnn Fellin, President Patricia McDonald spoke of the activities of the chapter for the 80's. Other speakers included Sister Helen Sullivan, moderator of the chapter for 23 of the 40 years. The festivities culminated with a reception where chapter scrapbooks, photo albums, and plaques were displayed. Other activities of the semester included a computer dance on 17 January and the Math Tournament for high school students on 8 March. On 27 March KS Gamma received into membership the following initiates: Teresa Beye,Amy Duffy, Thomas Gallagher, Dianne Hickert,Steven Pahls, and Leslie Peabody. Leo Vitt, newly elected president of the chapter, was awarded the Sister Helen Sullivan Scholarship for 1980-81. Other 80-81 officers: Richard Desko,vice president; Leslie Peabody,secretary; Dianne Hickert, treasurer; Amy Duffy, historian; Sister JoAnn Fellin, corresponding secretary.

Kansas Delta, Washburn University, Topeka
Chapter President-Rebecca Hladky
20 actives, 5 pledges

Spring semester activities included the usual monthly luncheon meetings. The chapter with help from the faculty sponsored Washburn Mathematics Day for high school students. Members also attended the regional convention at Western Illinois University. Randy Leimer received a second place award for his paper,"Graph Theory in Decision Making."Other 1980-81 officers: Paul Swank, vice president; Cindy Dietrich, secretary; Kathy King, treasurer; Robert Thompson, corresponding secretary; Gary Schmidt, faculty sponsor.

Kansas Epsilon, Fort Hays State University, Hays
Chapter President-Geralyn Kraus
21 actives, 12 pledges

Dr. William Welch of the Fort Hays State Physics Department spoke to the chapter on "Black Holes." Guest speaker for the annual spring banquet was Rev. David Lyon who gave a talk on Jerusalem and Israel. A spring picnic was enjoyed by mathematics students and faculty. Other 1980-81 officers: Don Jesch, vice president; Maxine Arnoldy, secretary and treasurer; Charles Votaw, corresponding secretary; Jeff Barnett, faculty sponsor.

Kentucky Alpha, Eastern Kentucky University, Richmond
Chapter President-Sally Fisher
14 actives, 14 pledges

Chapter members conducted weekly problem sessions for calculus and pre-calculus students during the fall and spring semesters. Meetings were held on a biweekly basis. Dr. Paul Bland gave a talk, "Fallacies in Mathematics" at the April 16 meeting. A pot luck dinner was held at the home of Dr. Dorian Yeager on April 19. Fourteen new members were initiated at that time. Other 1980-81 officers: Robin Woodward, vice president; Diane Kerr, secretary; Kevin Preston, treasurer; Dorian Yeager, corresponding secretary; Amy King, faculty sponsor.

Maryland Alpha, College of Notre Dame of Maryland, Baltimore
Chapter President-Cecilia Wintz
10 actives, 5 pledges

Student papers were presented during spring semester 1980 as follows: Maura Kelly-"Graph Theory;" Rita McCardell, "Microcomputers;" Ann Shaugnessy-"Women in Mathematics." At the annual spring supper, four students were inducted into KME. The featured speaker was Sister Delia Dowling. Her topic was "Confidence in Mathematics." Other 1980-81 officers: Rita McCardell, vice president and treasurer; Jane Skarda, secretary; Sister Marie Augustine Dowling, corresponding secretary; Sister Delia Dowling, faculty sponsor.

Maryland Beta, Western Maryland College, Westminster
Chapter President-Rebecca Weller
25 actives

At the spring banquet held on campus, two new members were inducted and Bill Link, a senior member, gave a talk on probability as related to gambling. Bill's talk was later expanded and refined and was a prize winner at the Region I meeting held at Shippensburg State College in April. The chapter also sponsored a career night with four math alumni from the Class of 1974 talking about their professional work (related and unrelated to mathematics). The chapter also sponsored a booth in the May Day Carnival, selling bagels to make some money. The year closed with a picnic to which all math majors were invited, which was held at the home of one of the faculty members. Other 1980-81 officers: James Wellman, vice president; Sally Carlson, secretary; Janet Carr, treasurer; James Lightner, corresponding secretary; Robert Boner, faculty sponsor.

Maryland Delta, Frostburg State College, Frostburg
Chapter President-James E. Martens
23 actives

Maryland Delta Chapter began the semester with the initiation of 15 pledges on February 3,1980,with a talk given by Dr. Reynaldo Azzi, a mathematics education specialist. In March the chapter sponsored a talk by Dr. Mary Gray of American University, an MAA Visiting Lecturer,on the topic "Statistics and the Law." Chapter members provided weekly tutoring to students of the non-major calculus course, supported by the campus Special Instructional Program. KME sponsored a high school student program in conjunction with the annual Mathematics Symposium sponsored by the department. Members prepared a mathematical puzzles contest and arranged for faculty speakers and other campus activities. Rounding out the semester were a talk by one of the senior members,Janet Jessup, a π(pie)-eating contest at the campus Bluegrass Fesitval, and a spring picnic at a nearby state park. Other 1980-81 officers: Peter Crickman, vice president; Douglas Cannon, secretary; John Mazz, treasurer; Agnes B. Yount,corresponding secretary; John P. Jones,faculty sponsor.

Massachusetts Alpha, Assumption College, Worchester
Chapter President-Anastos F. Chiavaras
17 actives

Fourteen new members were initiated on March 31,1980. Following a dinner in honor of the new members, Rev. Richard P. Brunelle, A. A., of the Assumption faculty, spoke on "Cryptology and Computer Security."Other 1980-81 officers: Richard J. Harper, vice president; Karen D'Alesio,secretary and treasurer; Charles Brusard, corresponding secretary and faculty sponsor.

Michigan Beta,Central Michigan University, Mt. Pleasant
Chapter President-Margaret McNally
60 actives, 24 pledges

Michigan Beta members were available three evenings per week for tutoring of students in undergraduate mathematics. Student presentations at meetings were on the following topics: Fibonacci numbers; Probabilities of card hands; Experience in an elementary classroom;

Mathematical games and recreation. The initiation speaker was Dr. Wilbur Waggoner of Central Michigan University (and National KME treasurer). His talk was about national honor societies and what membership in KME means. Mr. Allen Butterworth, head of the Mathematics Department of the General Motors Research Laboratories, gave a presentation on March 27 titled: "Challenges of Applying Mathematics to Industrial Problems." Other 1980-81 officers: John Gardner, vice president; Beth Babcock, secretary; Janice Jones, treasurer; Arnold Hammel, corresponding secretary and faculty sponsor.

Mississippi Alpha, Mississippi University for Women, Columbus

Chapter President-Mary Beth Weiss

25 actives, 16 pledges

Other 1980-81 officers: Robin Ficklin, vice president; Mary Ruth Krieger, secretary and treasurer; Jean Ann Parra, corresponding secretary and faculty sponsor.

Mississippi Gamma, University of Southern Mississippi, Hattiesburg

Chapter President-Ted Blaylock

40 actives

Fifteen members were initiated at the spring initiation and cookout on March 28, 1980. The following students gave talks at KME undergraduate seminars: J.O. Camp, "Mathematical Philosophy;" Elizabeth O'Neal, "Counting the Petals of Rose Curves;" Juanita Chase, "The Hyperbolic Paraboloid as a Solar Collector." The following students gave talks at the KME graduate seminar: Donna Pearce, "Computerized Tomography;" Ted Blaylock, "On the Metrizability of K_ω-spaces." Other 1980-81 officers: Obie Camp, vice president; Melissa Harris, secretary; Melissa Keeter, treasurer; Alice W. Essary, corresponding secretary; Temple Fay, faculty sponsor.

Missouri Alpha, Southwest Missouri State University, Springfield

Chapter President-Richard Robertson

51 actives, 10 pledges

Other 1980-81 officers: Jim Birkenbauch, vice president; Jayne Ward, secretary; Donna Garoute, treasurer; M. Michael Awad, corresponding secretary; L. T. Shiflett, faculty sponsor.

Missouri Beta, Central Missouri State University, Warrensburg
Chapter President-Danny Baker
26 actives, 17 pledges

Spring semester activities included the annual spring honors banquet,two other regular meetings, and election of officers. The annual Klingenberg lecture was given by a former KME member, William Fulkerson. Three members and a faculty sponsor attended the Region IV convention in Macomb, Illinois. Mike Fallin was awarded third place for his paper presented at the convention. Other 1980-81 officers: David Harris, vice president; Colleen Seitter, secretary; Terry Allen, treasurer; Homer F. Hampton, corresponding secretary.

Missouri Epsilon, Central Methodist College, Fayette
Chapter President-Janet Doll
4 actives, 1 pledge

Officers for 1980-81 are not elected until fall semester. William D. McIntosh is corresponding secretary and faculty sponsor.

Missouri Eta, Northeast Missouri State University, Kirksville
Chapter President-Karen Wulff
23 actives, 12 pledges

The chapter had a very active spring semester. Nine members attended the Region IV convention at Macomb, Illinois. Two KME teams reached the semi-finals of the all-campus bowl. Three members were then selected to a five-individual all-star team. Two guest speakers gave programs. KME members helped with special olympics on campus and assisted in correcting and proctoring exams for the N.M.S.U. high school academic contests. The chapter hosted a spring picnic for math students and faculty. Other 1980-81 officers: Denise Howard, vice president; Deb Hoyt, secretary; Tom Vespa,treasurer; Sam Lesseig, corresponding secretary;Mary Sue Beersman, faculty sponsor.

Nebraska Alpha, Wayne State College, Wayne
Chapter President-Shawnee Plock
26 actives

Throughout the semester, chapter members provided free tutoring service for students in pre-calculus and calculus courses. Members also assisted the mathematics department faculty in administering the Sixth Annual Wayne State College Mathematics Contest in which 410 high school students from 51 high schools participated. The KME Regional Convention in Macomb, Illinois was attended by Rod Bubke and Fred Webber. The Nebraska Alpha Chapter entered two teams in the Annual Wayne State College Bowl. The teams placed first and second respectively. Members of the winning team were Rod Bubke, Mike Jurgensen, Jody Meisinger and Shawnee Plock. Members of the second place team were Karen Reestman, David Sindelar, Mark Gehring, Lois Bright, Ruth Landers, Charles Johnson, and Kay Nichelson. At the Annual KME-LDL-Biology Club Spring Banquet, Dr. Fred Webber of the Mathematics Department was named Outstanding Professor of the Mathematics and Science Division for the year. Also at the banquet, Susan Schrage of Elgin, Nebraska was named Outstanding Freshman in Mathematics. The award includes the recipient's name being engraved on a permanent plaque, one year honorary membership in the local KME chapter and announcement of this honor at the annual banquet. Other 1980-81 officers: Rod Bubke, vice president; Jody Meisinger, secretary-treasurer; Ruth Landers, historian; Fred Webber, corresponding secretary; Jim Paige and Hilbert Johs, faculty sponsors.

Nebraska Beta, Kearney State College, Kearney
Chapter President-Annette Herz
25 actives, 2 pledges

Other 1980-81 officers: Bob Gintzler, vice president; Joy Kenton, secretary; Patty Welch, treasurer; Charles Pickens, corresponding secretary; Marilyn Jussel, faculty sponsor.

New Mexico Alpha, University of New Mexico, Albuquerque
Chapter President-Bill Short
30 actives

Other 1980-81 officers: Mike Prairie, vice president; Carmen Montoya, secretary; Fred Ream, treasurer; Merle Mitchell, corresponding secretary and faculty sponsor.

New York Eta, Niagara University, Niagara
Chapter President-Mary Heneghan
17 actives, 3 pledges

The chapter was active in selling carnations to raise money for subsidizing the annual initiation banquet. The banquet speaker this year was Tom Jones, an alumnus who was able to give advice and encouragement to undergraduates. The chapter also co-sponsored an end-of-the year picnic in conjunction with the Math Club. Other 1980-81 officers will be elected in the fall semester.

New York Theta, St. Francis College, Brooklyn
Chapter President-Kevin Marino
4 actives, 3 pledges

Other 1980-81 officers: Chris Cirillo, vice president; Charles Benette, secretary-treasurer; Rosalind Guaraldo, corresponding secretary and faculty sponsor.

New York Iota, Wagner College, Staten Island
Chapter President-Michele Giaimo
9 actives, 5 pledges

New members were inducted on April 21, 1980. A prospective faculty member gave a talk on "Infinite Matrices" at a regular meeting. The annual KME dinner was held May 3, 1980. Other 1980-81 officers: Kevin Padula, vice president; Robert Hastedt, secretary; Keith Cerasolie, treasurer; William Horn, corresponding secretary and faculty sponsor.

New York Kappa, Pace University, New York
Chapter President-Michael Schiano
30 actives, 15 pledges

The annual induction and dinner were held on March 26, 1980. The fifteen inductees were Barbara Antes, Robert Bauer, Peter Brown, Maria Claudino, Pasqualina Mazzella, Jacquenetta Morsette, Josephine Mugavero, Judy Ann Parlato, Rose Rossetti, Patricia Desiano, Andrea Dick, Theresa Dolan, Constance A. Picciano, Paula Wandzilak, Prof. Jeff Rubens. New York Kappa was proud to have Dr. Fred Buckley as guest speaker for this occasion. Dr. Buckley did his undergraduate studies at Pace, and he is currently an assistant professor of mathematics at St. John's University. Other 1980-81 officers: Lisa Fauci, vice president; Lorraine Fu, corresponding secretary; Martin Kotler, faculty sponsor.

Ohio Alpha, Bowling Green State University, Bowling Green
Chapter President-Kathy Engel
28 actives, 22 pledges

Twenty-two new members were initiated at the spring banquet and awards ceremony. Guest speaker, Dr. Josef Blass spoke on "Forecasting Inflation." Other 1980-81 officers: Chris McCord, vice president and treasurer, Barbara Williams, secretary; Waldemar Weber, corresponding secretary; Josef Blass and William Kirby, faculty sponsors.

Oklahoma Gamma, Southwestern Oklahoma State University, Weatherford
Chapter President-Troy Harden
25 actives

Dr. Leroy Folks from Oklahoma State University was a guest speaker at a spring meeting. The chapter also held an end-of-school picnic. Officers for 1980-81 are elected in the fall. Wayne Hayes is corresponding secretary.

Pennsylvania Alpha, Westminster College, New Wilmington
Chapter President-Sue Gotkiewicz
45 actives, 20 pledges

The chapter sponsored a MATH FLICKS night for the college community with movies "Donald in Mathmagic Land," "Powers of Ten," and a slide show on the work of M. C. Escher. The initiation banquet was held at the Sheraton with the new initiates providing entertainment. Members sponsored a booth at the Westminster Spring Carnival on computer games on the Mathematics and Computer Science Departments Compucolor. A spring picnic was held on a cold day at a local park. Other 1980-81 officers: Becky Wheat, vice president; Mary Boyer, secretary; Bill Dzuricsko, treasurer; Barbara T. Faires, faculty sponsor.

Pennsylvania Beta, LaSalle College, Philadelphia
Chapter President-Terry Gauder
30 actives

Membership certificates were given to twenty new members initiated in the fall at the April 15 meeting. Dr. Carl McCarty spoke on "Counting Shapes." Other 1980-81 officers: Holly Reedinger, vice president; Nancy McGee, secretary; Joann Lawler, treasurer; Hugh N. Albright, corresponding secretary; Carl McCarty, faculty sponsor.

Pennsylvania Gamma, Waynesburg College, Waynesburg
Chapter President-Kimberly Hemskey
28 actives

PA Gamma attempted to have a Regional Meeting in April but had to cancel due to lack of response from other chapters. The chapter held its annual spring banquet on April 25. The president of Gamma chapter for the first semester, 1979-80,David Dell,was the salutatorian for the senior class, which graduated May 18, 1980. Other 1980-81 officers: Charlene Daniels, vice president:Anna Hofnagle, secretary and treasurer; Rosalie B. Jackson, corresponding secretary; David S. Tucker, faculty sponsor.

<u>Pennsylvania Epsilon</u>, Kutztown State College, Kutztown
Chapter President-George Malafarina
28 actives

Spring activities included a games night, a talk on new ideas in home computers, and an initiation banquet. Other 1980-81 officers: Kim Ebert, vice president; Linda Marcinkus,secretary; Matthew Schaeffer,treasurer; Irving Hollingshead, corresponding secretary; Edward W. Evans, faculty sponsor.

<u>Pennsylvania Zeta</u>, Indiana University of Pennsylvania, Indiana
Chapter President-Debra Mentch
26 actives

Ten new members were initiated at the February meeting. Dr. Joseph Angelo of the mathematics department gave a talk entitled "Logic by Osmosis." Mr. Raymond Gibson of the mathematics department spoke at the March meeting. His topic, "A Speech that isn't a Speech," was an interesting presentation of many different applications of Pascal's Triangle. The May meeting was the spring banquet. Guest speaker was Miss Margaret Lambert, Indiana area senior high school teacher who related her experiences in attaining a B.S. in Electrical Engineering degree. Other 1980-81 officers: Terry Sheaffer, vice president; Loretta Kachline, secretary; Michele Stelma, treasurer;Ida Z. Arms, corresponding secretary; William R. Smith, faculty sponsor.

<u>Pennsylvania Eta</u>, Grove City College, Grove City
Chapter President-Val Olbreck
15 actives, 13 pledges

The spring picnic was held at the Country Club on May 5, 1980. Hot dogs and hamburgers were cooked over a charcoal grill and the faculty wives provided desserts and other dishes. Unfortunately,a late afternoon shower put an early end to the affair. Other 1980-81 officers: Ruth Radakovic,treasurer; Marvin C. Henry,corresponding secretary; John Ellison, faculty sponsor.

Pennsylvania Theta, Susquehanna University, Selinsgrove
Chapter President-David Scicchitano
10 actives

Four members presented papers at the Region I convention. David Scicchitano received a first place award for his presentation. The chapter held a banquet and initiation in January. Members provide tutorial service for the mathematics department. Other 1980-81 officers: Robert Pickert,vice president; Jo Kleinfelter,secretary and treasurer; Carol N.Harrison,corresponding secretary and faculty sponsor.

Pennsylvania Iota, Shippensburg State College,Shippensburg
Chapter President-Burt Meyers
28 actives, 10 pledges

The major spring activity was that of hosting the Region I convention April 11-12, 1980. A summary of the convention is highlighted earlier in this issue. Other 1980-81 officers: Sharon Hill, vice president; Joanne McGonigle,secretary; Howard Bell, treasurer; Carl Kerr, corresponding secretary; Winston Crawley, faculty sponsor.

Pennsylvania Kappa, Holy Family College, Philadelphia
Chapter President-Suzanne Moriat
5 actives, 6 pledges

Members of KME attended the National Council of Teachers of Mathematics Convention held in Cherry Hill, N.J. on March 13-15, 1980. Discussions were held on March 20, 1980 meeting about the various lectures they attended and how they broadened their insight into the relevance of mathematics in today's world. Twenty dollars were given by the members to purchase books for the library. Members help tutor in the Math Center. Plans are being made to invite graduate members of KME to the next meeting in the fall 1980. Other 1980-81 officers: Judith Washburn,vice president and secretary; Jan Buzydlowski, treasurer; Sister M. Grace, faculty sponsor.

Pennsylvania Mu, St. Francis College, Loretto
Chapter President-D. Kevin Horner
20 actives, 3 pledges

The three new members were inducted March 26, 1980. Other 1980-81 officers: Diane M. Zelnosky, vice president; Marsha A. Oakes, secretary; Catherine J. Burns, treasurer; Fr. John Kudrick, corresponding secretary; Adrian Baylock, faculty sponsor.

South Carolina Gamma, Winthrop College, Rock Hill
Chapter President-Mary Pridgen
21 actives, 4 pledges

Dr. John Kinloch of East Tennessee State University presented a program on the history of mathematics.Other 1980-81 officers: Grant White, vice president; June High, secretary; Abby Raines, treasurer; Donald Aplin, corresponding secretary; Bill Hodges, faculty sponsor.

Tennessee Beta, East Tennessee State University,Johnson City
Chapter President-Eric Bowman
29 actives, 16 pledges

In April, the chapter attended the Mathematical Association of America meeting held in Boone, N.C., Appalachian State University. In May the annual initiation service was held. Following a meal and a talk,sixteen students were initiated into KME. The officers conducted the initiation ceremony. Other 1980-81 officers: Karen Pierce, vice president; Cheryl Ponder, secretary; Lyndell Kerley, corresponding secretary and faculty sponsor.

Tennessee Gamma, Union University, Jackson
Chapter President-Nancy Blass
19 actives

The Annual Initiation Banquet was held on April 29, 1980. New members initiated were Melissa Alexander, David Barham, Jill Bradbury, Donna Humphreys, Don Mayberry, Stuart McClain, Judy Pafford,Gary Quinn, and Ray Vunk. Other 1980-81 officers: Stuart McClain, vice president; Jill Bradbury, secretary; Melissa Alexander, treasurer; Judy Pafford, reporter and historian;Richard Dehn, corresponding secretary; Joe Tucker,faculty sponsor.

Texas Alpha, Texas Tech University, Lubbock
Chapter President-Beverly Winters
25 actives, 10 pledges

Other 1980-81 officers: Mary Burton, vice president; Dawn Malone, secretary; Lon Young, treasurer, Monty Strauss, corresponding secretary and faculty sponsor.

Texas Eta, Hardin-Simmons University, Abilene
Chapter President-Jana Davis
47 actives, 3 pledges

Texas Eta Chapter held its annual spring induction banquet Friday, March 28, 1980. The new inductees are Torey Deatherage of Abilene, David Proctor of Abilene, and Debbie Smith of Lubbock. The program included a film entitled "Predicting at Random" featuring Professor David Blackwell of the University of California at Berkeley. Officers for 1980-81 will be elected in the fall. Anna B. Bentley, corresponding secretary; Charles D. Robinson, faculty sponsor.

Virginia Alpha, Virginia State University, Petersburg
Chapter President-Michael Parker
15 actives

The activities for the Chapter included student papers at monthly meetings, a banquet, an initiation at which six new members were inducted, a joint picnic with the Mathematics Club, and a trip to NASA at Hampton, Va. Donna Burke and William Echols received plaques from KME for outstanding performance in mathematics. Virginia Alpha Chapter also gives an annual award to an outstanding junior mathematics major. This award, the Louise Stokes Hunter Award, named in honor of Dr. Hunter, Professor Emeritus and founder of Virginia Alpha Chapter of KME, was given to Michael Parker. Other 1980-81 officers: Harrison Ransom, vice president; Debra Johns, secretary; Martina Lewis, treasurer; Laverne Goodridge, corresponding secretary; Emma Smith, faculty sponsor.

West Virginia Alpha, Bethany College, Bethany
Chapter President-Bart Balint
15 actives, 9 pledges

The chapter held its annual meeting for induction of new members and election of new chapter officers. New members are Bart Balint, Todd DeSantis, Ross Fowler, Marcy Hurl, Chris Langston, Dr. William Leech, Kathy

Madison, Cindy Marks, and Pat White. Other 1980-81 officers: Kathy Madison, vice president; Teryl Berriman, secretary, treasurer, and historian; James Allison, corresponding secretary and faculty sponsor.

Wisconsin Alpha, Mount Mary College, Milwaukee
Chapter President-Mary Pat Ganzer
7 actives, 4 pledges

The chapter conducted its annual Mathematics Contest for Young Women, March 29, 1980. Thirty-six students from eleven different schools participated. Each of the four initiates gave a talk: Monica Iannelli on "The Binary System;" Marie Schwerm on "What Numbers on a Wisconsin Driver's License Mean;" Heather Shelton on "Probability and Genetics;" Lynne Zaborske on "The Metric System." One of the students preparing to do student teaching next fall taught a discovery lesson to the KME members. Four new members were initiated on April 25, 1980. After the formal initiation, the entire group plus some KME alumnae went to one of the initiate's home for dinner. Everyone had a very pleasant evening. Other 1980-81 officers: Marie Schwerm, vice president; Monica Iannelli, secretary; Heather Shelton, treasurer; Sister Mary Petronia VanStraten, corresponding secretary and faculty sponsor.

Wisconsin Beta, University of Wisconsin, River Falls
Chapter President-Gail Norderhaug
41 actives, 8 pledges

Eight new members were initiated this spring semester. A guest speaker from the 3M company gave the program at this initiation. The chapter assists the faculty with tutoring of mathematics students. It was decided to form the mathematics club again for all mathematics students. Other 1980-81 officers: Bryce Peters, vice president; Terry Paulson, secretary; James Griffin, treasurer; Lyle Oleson, corresponding secretary; Ed Mealy, faculty sponsor.

Wisconsin Gamma, University of Wisconsin, Eau Claire
Chapter President-Beth A. Magnuson
31 actives, 11 pledges

The chapter held monthly meetings with a student speaker at each. Topics of the student talks were Lobachevskian Geometry, a proof of the real number system, statistics in relation to poll-taking, and the Abacus.

Eleven new members were initiated at the annual spring banquet on February 24, 1980. Steve Nelson from Gray Research Inc.spoke on modern computers versus the human brain. As part of the University's honors week activities Wisconsin Gamma hosted a Math Bowl on April 25,1980 with the Universities of Wisconsin from River Falls and Stevens Point. Other activities during the spring semester included bowling,and a picnic with the computer club. Other 1980-81 officers: Laura D. Newman, vice president; Sandy Hop, secretary; Elizabeth Challoner, treasurer;Alvin Rolland,corresponding secretary; Thomas Wineinger, faculty sponsor.

INSTALLATION OF NEW CHAPTERS

EDITED BY LORETTA K. SMITH

Information for this department should be sent to Mrs. Loretta K. Smith, Hillcrest Road, Orange, Connecticut 06477.

TEXAS THETA CHAPTER

Southwest Texas State University, San Marcos, Texas

The installation of the Texas Theta Chapter of Kappa Mu Epsilon was held on 25 April 1980. Dr. Harold L. Thomas, National Historian of Kappa Mu Epsilon, conducted the installation ceremony. The following students were initiated into the society as charter members:

Michael Ferris
Rory L. Foster
Cathy Gavloski
Rebecca Jaster
Allen Kiesling
Kay Kuester
Kathy McVey
Angie Sims
Rhonda Kay Thielen
James E. Turner

Mathematics faculty members, Dr. Carroll Bandy and Mr. Daniel Lee, were also initiated as charter members.

Assuming the responsibilities of officers of Texas Theta are: Rory Foster, president; Kathy McVey, vice president; Allen Kiesling, secretary; Kay Kuester, treasurer; Daniel Lee, faculty sponsor; Carroll Bandy, corresponding secretary.

Following the installation ceremony Dr. Thomas gave a talk on the history of Kappa Mu Epsilon.

ILLINOIS THETA CHAPTER

Illinois Benedictine College, Lisle, Illinois

The Illinois Theta Chapter of Kappa Mu Epsilon was installed at Illinois Benedictine College in Lisle, Illinois on 18 May 1979 by the immediate past Historian of Kappa Mu Epsilon, Sister Jo Ann Fellin. Sister Nona Mary Allard of Illinois Zeta, as conductor, introduced the following students for acceptance as charter members:

Alan Burnham	Kristi Keeler
Michael Davern	Lisa Kozloski
John Doherty	Maureen Maney
Steven Earle	Judith Nocek
Robert Gallee	Susan Rudzinski
Gregory Gorski	Mahnaz Shahidi
Patricia Gramme	David Spokas
James Haidu	Chung Cheng Tai
Dennis Harkin	Kerry Vrabel
Joseph Jirka	Mary Vrtis

The following faculty members were initiated as charter members of Illinois Theta: Rose Carney, Eileen Clark,Phyllis Kittel, Father Richard Shonka, and Father Paul Tsi. Faculty member Marvin Camburn,already a member of Kappa Mu Epsilon, will join in Illinois Theta activities.

Assuming the responsibilities of officers of Illinois Theta are: Mary Vrtis, president; Lisa Kozloski, vice president; Patricia Gramme, secretary; Mahnaz Shahidi, treasurer; Phyllis Kittel, corresponding secretary and faculty sponsor.

Following the installation ceremony Sister Jo Ann Fellin gave a slide presentation which emphasized the values of learning and fellowship as seen in the lives of men and women mathematicians.

A reception completed the installation festivities.

Reminder that the Twenty-third Biennial Convention of Kappa Mu Epsilon will be held in Springfield, Missouri April 2-4, 1981. For details concerning students papers, see page 135 in the Spring, 1980 PENTAGON.

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