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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.

AS THE WATER SWIRLS

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Mathematics can be applied in many ways. It can be used as a basis for many other fields of study. Applied mathematical concepts can help us understand the world around us. It can give us concrete reasons why things in nature happen and what causes them. For example, look at a sink full of water that is draining. One notices that the water swirls in either a clockwise or a counterclockwise direction. This paper will deal with the questions: "Why does this happen?" and "In what direction will the water swirl?" The problem posed is a basic physics problem that can be developed intuitively, but it will also be developed in mathematical steps to explain why the water rotates as it does.

To understand intuitively which direction water swirls we will use an example of an airplane flying and then compare this to the motion of the water in the sink. Assume an airplane is flying south from the North Pole to New York City. The plane leaves the North Pole and heads south in a straight line directly toward New York. The plane lands and misses New York City.

Instead it lands to the west, near Chicago. A force must have caused the airplane to go to the west. However no force acted on it, therefore, we will refer to it as a pseudo force, a false force that is not really present.

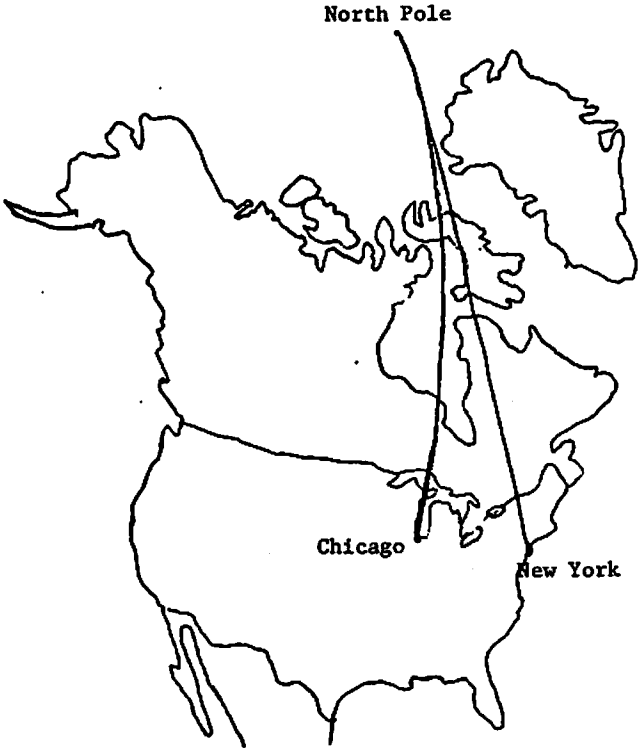

Figure 1

Intuitively one can see why this would happen. We will assume that the plane heads south at a constant velocity. The direction of the plane is set when it takes off and is not changed during the flight. Some force which we can not account for moved the plane to the west. Now if we look at the velocity again, but from a point in space, we can see that the plane has the same southern velocity as before. However, it also has a western velocity due to the rotation of the earth. So when the plane takes off, it has southern and western components in its velocity relative to the earth. This accounts for the other force acting on the plane. However, this does not completely resolve the problem, for as New York is rotating around the axis of the earth so is the North Pole. Thus, it seems again that the plane should land at its destination.

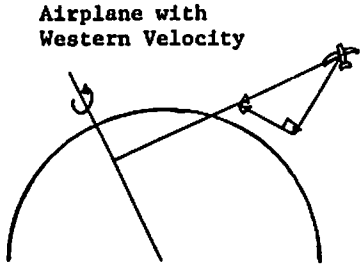

Figure 2

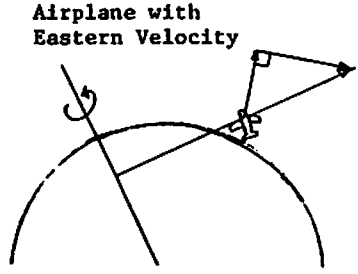

Figure 3

To solve this dilemna, we must also take into account the amount of eastern velocity received by the plane when it takes off. It receives the amount of eastern velocity of the North Pole. The eastern velocity would be the distance of the North Pole from the axis on which the earth rotates, multiplied by the angular frequency of rotation of the earth. Now, New York also has an eastern velocity which is measured the same way as that for the North Pole. Now we must remember that the shape of the earth is a sphere. This makes the distance to the axis of rotation vary depending on where you are located on the sphere. The distance from New York to the axis is greater than that of the North Pole to the axis, for the North Pole is basically on the axis. This causes New York to have a greater eastern velocity than the North Pole and the plane. As the plane flies south, its eastern velocity is less than that of the land that it is crossing, therefore, it goes to the west in comparison to the land. When it arrives near New York, it is to the west because of its lower eastern velocity. Now we have identified the pseudo force, which is called the Coriolis force, that caused the plane to miss its target. Basically the same thing happens if you are flying a plane north from New York to the North Pole.

The eastern velocity of the plane is greater than that of the land it is crossing, so it will miss the North Pole.

Now suppose that you are flying a plane from Seattle to New York. You set the direction of the plane east. The plane misses New York and lands in South America. Again a psuedo force acted on the plane, this time forcing it to the south.

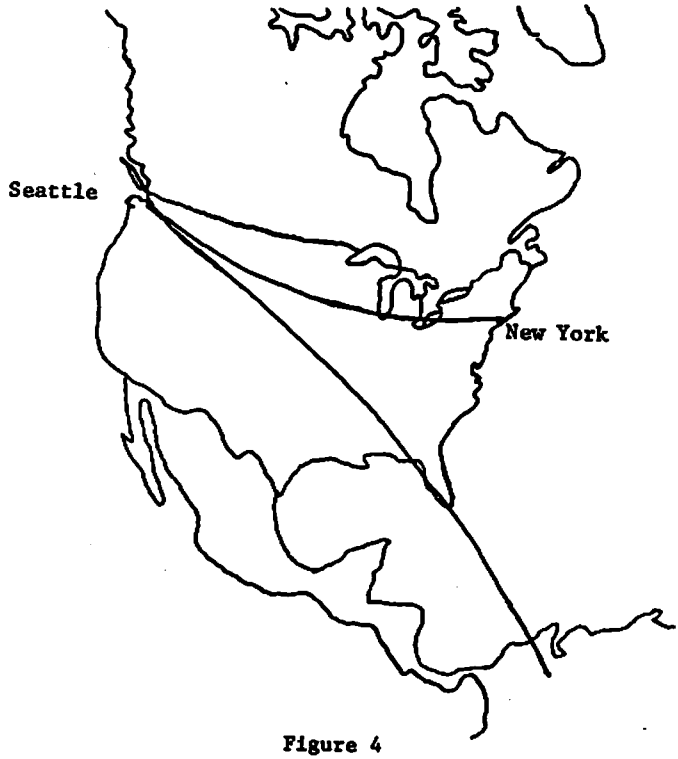

Figure 4

When the plane is in the air there is a force on it pulling it toward the earth. This is called centripetal force. If you are on the surface of the earth this is the only force you see acting. Since the plane does not fall from the sky due to the centripetal force, there must be some force counteracting the centripetal force. This countering force is called the centrifugal force. If we look at the airplane from a point in space, then we see the earth as it is rotating and there is a force pushing the plane outward as the earth rotates. This is just like swinging an object on the end of the string. The object has an outward force; centrifugal, and the string applies the force that pulls it back in; centripetal. As the object rotates faster the outward force is felt to be greater; if it rotates slower the outward force is less. This is the same concept that is applied to the airplance. As the airplane is moving east toward New York, its velocity equals the eastern velocity it receives from the rotation of the earth plus its eastward velocity. So the velocity of the plane is faster relative to the things around it. Now it has a greater centrifugal force acting on it because it is rotating at a faster velocity. So, relative to the things around it, the plane feels more of a centrifugal force radially out from the axis of the earth. This

force has a velocity component away from the axis, but due to the shape of the earth this is not straight up relative to the surface of the earth. The shape of the earth causes the force to have an upward component and a outhward component. Finally, here is the source of another pseudo force, called the centrifugal force, that causes the plane to drift to the south as it flies east toward New York.

The reverse would happen if the plane was traveling directly west from New York to Seattle. The plane would end up north of Seattle. The velocity of the plane is east due to the rotation of the earth, minus its own western velocity. Therefore, the plane has a velocity less than the things around it. The slower velocity makes the plane have less centrifugal force than other things relative to it. This causes the plane to move toward the axis of rotation. Again, due to the shape of the earth, the force has a component downward and a component to the north relative to the surface of the earth as it is flying west toward Seattle.

Generally it has been shown that there is a force on an object moving in a rotating system. Notice that all the examples took place in the northern hemisphere, therefore one can observe that in the northern hemisphere a force to the right of the direction of

motion is felt due to the rotation of the earth. Now if you go to the southern hemisphere, it can be shown, in the same manner as before, that a force to the left of the direction of motion is felt due to the rotation of the earth.

Mathematically this process can be described by using two frames of reference and showing how things move about in one system relative to the other. Now let's consider two coordinate systems, the X system and the Y system. The X coordinate system has orthonormal basis, $\{\hat{x}_1, \hat{x}_2, \hat{x}_3\}$, and the Y system has orthonormal basis, $\{\hat{y}_1, \hat{y}_2, \hat{y}_3\}$. The Y system relates to the observation of the plane from the earth. While the X system relates to observation from space.

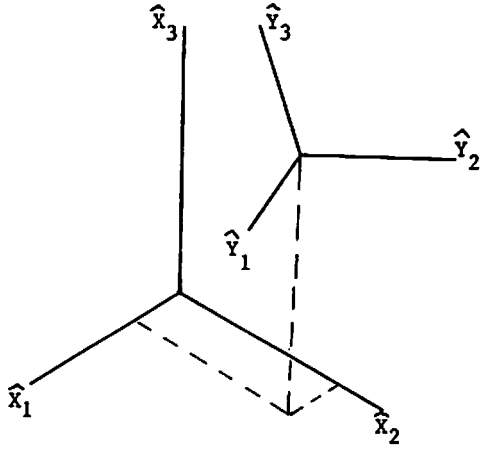

Figure 5

A vector $\vec{R}$ can be expressed in terms of either coordinate system.

$$\vec{R} = x_1(t)\hat{x}_1 + x_2(t)\hat{x}_2 + x_3(t)\hat{x}_3$$

or

$$\vec{R} = y_1(t)\hat{y}_1 + y_2(t)\hat{y}_2 + y_3(t)\hat{y}_3$$

Now set the Y coordinate system rotating around an axis $\overrightarrow{QP}$ which goes through the origin of the X system. $\vec{R}$ in the Y coordinate system is not moving but in the X system $\vec{R}$ is rotating around the axis $\overrightarrow{QP}$.

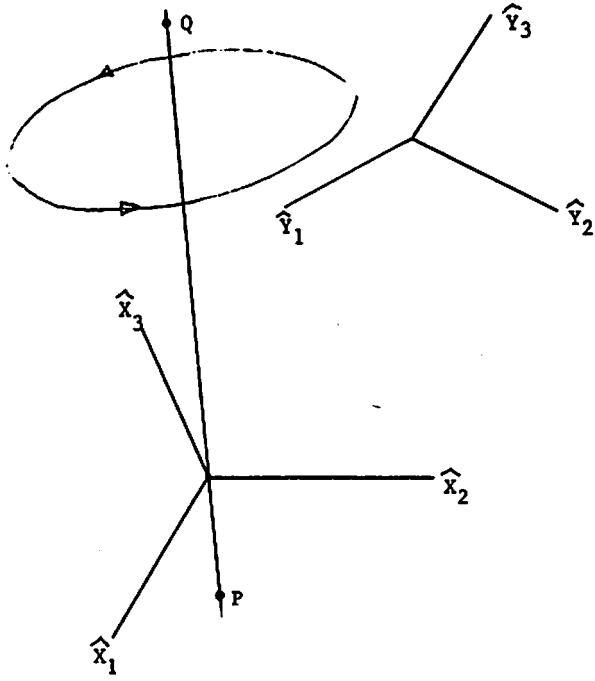

Figure 6

The problem is to find the equation of motion of $\vec{R}$ in the X system relative to the Y system. The equation of motion is Newton's second law; F=ma. This means that a force, F, equals the mass of an object, m, multiplied by its acceleration, a. This force can be found if the position vector of an object and its mass are known. The time derivative of the position vector can be taken to obtain the velocity. Then the time derivative can be taken of the velocity to obtain acceleration. By knowing the acceleration one can solve the equation of motion for the forces acting on a mass. The time derivative of any $\vec{R}$ is

$$\frac{d\vec{r}}{dt} = \lim_{\Delta t \to 0} \frac{\vec{R}(t + \Delta t) - \vec{R}(t)}{dt} \qquad (1)$$

The velocity of $\vec{R}$ in the X system is

$$\frac{d^{x}\vec{R}}{dt} = x_1'(t)\hat{x}_1 + x_2'(t)\hat{x}_2 + x_3'(t)\hat{x}_3 \qquad (2)$$

The velocity of R in the Y system is

$$\frac{d^{y}\vec{R}}{dt} = y_1'(t)\hat{y}_1 + y_2'(t)\hat{y}_2 + y_3'(t)\hat{y}_3 \qquad (3)$$

If the Y system is observed from the X system the orthogonal unit vectors of the Y system become functions of time.

$$\vec{R} = y_1(t)\hat{y}_1(t) + y_2(t)\hat{y}_2(t) + y_3(t)\hat{y}_3(t)$$

Now if we express the velocity of $\vec{R}$ in the X system in terms of the Y system we get

$$\frac{d^{y}\vec{R}}{dt} = y_1'(t)\hat{y}_1(t) + y_2'(t)\hat{y}_2(t) + y_3'(t)\hat{y}_3(t) + y_1 t\frac{d\hat{y}_1(t)}{dt} + y_2(t)\frac{d\hat{y}_2(t)}{dt} + y_3(t)\frac{d\hat{y}_3(t)}{dt} \qquad (4)$$

The first three terms show how $\vec{R}$ is moving in the Y system; the last three terms show how the Y system is moving relative to the X system. Now suppose that the Y system is rotating around the axis $Q\vec{P}$ with angular velocity $\vec{w}$.

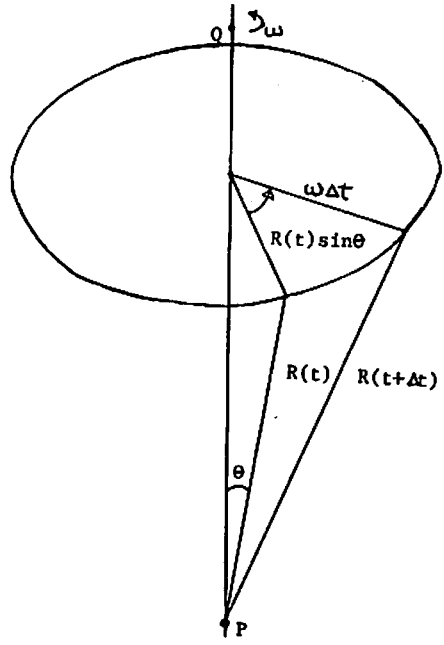

Figure 7

By looking at figure 7, it can be seen that the tip of $\vec{R}$ is at distance $|\vec{R}(t)|\sin\theta$ from the axis of rotation. In a change in time, Δt, $\vec{R}$ moves through the angle $\vec{\omega}\Delta\vec{t}$. By assuming that Δt is small the angle is small. Then we can show that the distance $\vec{R}$ moved in the time Δt is approxiamately $\vec{\omega}\Delta t|\vec{R}(t)|\sin\theta$. Referring to equation (1) we shall call the distance $\vec{R}$ moved in Δt, $\vec{R}(t+\Delta t)-\vec{R}(t)$, which is the change in $\vec{R}$, $\Delta\vec{R}$. Therefore, $|\Delta\vec{R}|=\vec{\omega}\Delta t|\vec{R}(t)|\sin\theta$. By rearranging this equation we get

$$\frac{\Delta\vec{R}}{\Delta t} = \vec{\omega}\vec{R}(t)\sin\theta$$

Referring to equation 1 it is seen that

$$\lim_{\Delta t\to 0} \frac{\Delta R}{\Delta t} = \frac{d\vec{R}}{dt}$$

Remember that $\dot{\omega}|\vec{R}(t)|\sin\theta=|\vec{\omega}X\vec{R}(t)|$ by the definition of cross product. So we see that the derivative of $\vec{R}$ in terms of the Y system is $\vec{\omega}X\vec{R}$.

$$\frac{d\vec{R}}{dt} = \vec{\omega}X\vec{R} \qquad (5)$$

Now equation (4) can be rewritten by substituting in equation (2).

$$\frac{d^x\vec{R}}{dt} = \frac{d^y\vec{R}}{dt} + y_1(t)\frac{d\hat{y}_1(t)}{dt} + y_2(t)\frac{d\hat{y}_2(t)}{dt} + y_3(t)\frac{d\hat{y}_3(t)}{dt}$$

Then by using equation (5) we get

$$\frac{d^{x2}\vec{R}}{dt} = \frac{d^{y}\vec{R}}{dt} + (\omega XR) \qquad (6)$$

to find the acceleration of $\vec{R}$ we take the derivative again and get

$$\frac{d^{x}{}^{2}\vec{R}}{dt} = \frac{d^{y}}{dt}\frac{d^{y}\vec{R}}{dt} + \frac{\omega x d^{y}\vec{R}}{dt} + \frac{d^{y}\vec{\omega}X\vec{R}}{dt}$$

Then by using equation (6) we obtain

$$\frac{d^{x}{}^{2}\vec{R}}{dt} = \frac{d^{y}{}^{2}\vec{R}}{dt} + 2m\vec{\omega}Xd^{y}\vec{R} + \vec{\omega}X(\vec{\omega}X\vec{R}) + \frac{d^{y}\vec{\omega}}{dt}XR \qquad (7)$$

Now equation (7) can be substituted into the equation of motion.

$$F = m\frac{d^{2}\vec{R}}{dt} + 2m\vec{\omega}X\frac{d\vec{R}}{dt} + m\vec{\omega}X(\vec{\omega}X\vec{R}) + m\frac{d\vec{\omega}}{dt}X\vec{R} \qquad (8)$$

This equation can be rearranged into standard form.

$$m\frac{d^{2}\vec{R}}{dt} = F - 2m\vec{\omega}X\frac{d\vec{R}}{dt} - m\vec{\omega}X(\vec{\omega}X\vec{R}) - m\frac{d\vec{\omega}}{dt}d\vec{R} \qquad (9)$$

All the terms after F are pseudo forces. They act on a mass that is moving in one coordinate system (Y system) while that system is rotating around an axis relative to another system (X system). The first term to the right is the force giving the mass, the beginning magnitude and direction. The second term is the negative of the coriolis force. The negative of the centrifugal force is the third term while the last term is the force that appears only when there is non-uniform rotation around the axis.

We can show that the example of the plane fits equation (9). The forces can be shown to be acting on the airplane when it is flying. The plane is flying at a constant velocity and we are observing it from the surface of the earth; the plane in the Y system is observed from the Y system. The first term of equation (9) is zero, for the plane is not accelerating. There is no coriolis force, for there is no rotation being accounted for. Also the centrifugal force and the last term are zero because of no rotation. Thus, there is no net force acting on the plane when we observe it from the surface of the earth. This is consistent with what we observed.

Now when we observe the plane flying from space, we see the forces acting upon it. The first term is zero because of the constant velocity of the plane and the last term is zero assuming the earth rotates at a constant velocity. There will be a coriolis and a centrifugal force because of the rotation and the velocity. The magnitude of these forces depend on the direction of motion. When the plane is going north or south the coriolis force acts on the direction of the plane. The centrifugal force is acting, but it is in a vertical plane so it does not effect the direction of motion. When the plane is directed east or west, the

coriolis force acts in a vertical plane, therefore not affecting the direction. However the centrifugal force does affect it. The coriolis and centrifugal forces act 90 degrees to the right of the direction of motion. This is only true for motion in the northern hemisphere. In the southern hemisphere, the forces are 90 degrees to the left. Therefore, if there is motion, there will be a force acting on it 90 degrees to the direction of motion. This is due to the coriolis effect, the pseudo force.

Now we will return to the original problem. Why does the water swirl in a certain direction as it goes down the drain? The water particles act just like the plane. They are moving and the earth rotates under them. This causes the water particles to be subjected to the coriolis effect, in the same way as the plane. When the drain is opened, the individual water particles each have a velocity directed downward and a velocity toward the drain. The velocity in the direction toward the drain is acted on by the coriolis and centrifugal forces. This causes the water particles to move in the direction of the force, thus, the water starts to swirl counterclockwise in the northern hemisphere and clockwise in the southern hemisphere.

Direction of
Water Particles

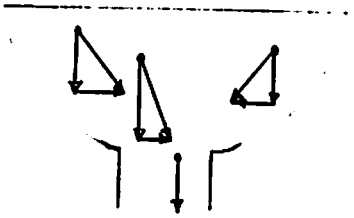

Figure 8

Force on
Water Particles

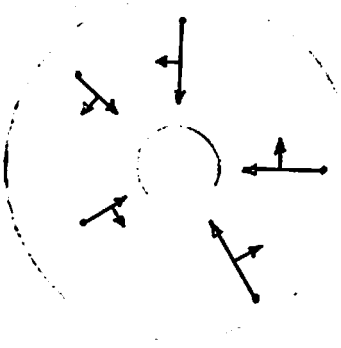

Figure 9

It is very hard to demonstrate and get the proper direction of swirl. Water will swirl in either direction, in either hemisphere. The coriolis effect, which is very small, will determine the direction of the swirl of water, but only under nearly perfect conditions. The water must be perfectly still before the drain plug is pulled. This means that the water must set for several hours or the rotation it received when it was put into the sink will affect it as it

drains out. Also, the drain must be opened without disturbing the water. If these conditions are met, then one can observe the water swirling in the proper direction.

In conclusion, in this paper it has been shown that there are mathematical reasons why water swirls in a certain direction as it drains. It is due to the earth rotating underneath the water. An example of an airplane was used to illustrate the coriolis effect. The coriolis effect was then related to water. Mathematical reasoning was used to prove what was developed intuitively; thus, showing that the basic physics problem is mathematically based. One can now conclude that applied mathematics is valuable in other fields of science; it can show concrete reasons for things that happen in nature. Applied mathematics can lead to a better understanding of the world around us.

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AN APPLICATION OF LINEAR ALGEBRA

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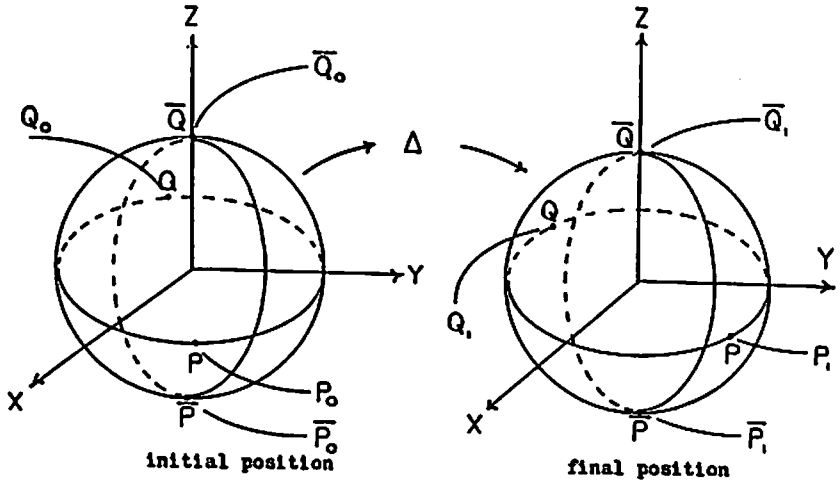
In this paper we are going to use various concepts in linear algebra, such as linear mappings and special mappings that preserve distance called isometries to prove the following hypothesis.

Let P and Q be any two points on the surface of the sphere in figure 1. Let P_o and Q_o denote the $\mathbb{R}^3$ coordinates of P and Q respectively in the sphere's initial position. Now let the sphere move through any sequence of rotations about the origin. Let Δ denote this sequence of rotations. Let P_1 and Q_1 denote the $\mathbb{R}^3$ coordinates of P and Q respectively in the sphere's final position after Δ. For any Δ, there exists distinct points $\bar{P}$ and $\bar{Q}$ such that $\bar{P}_o = \bar{P}_1$ and $\bar{Q}_o = \bar{Q}_1$. In other words no matter what Δ is used, two points will always return to their initial positions after Δ.



Δ: $\pi/4$ about the Z-axis

Figure 1

Let X_0, Y_0, Z_0 denote the matrix representations of the linear mappings that rotate vectors in $\mathbb{R}^3$, about the X,Y, and Z axis respectively. Then

$$\begin{vmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{vmatrix} \qquad \begin{vmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{vmatrix}$$

$$\begin{vmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

are X_θ, Y_θ, Z_θ respectively. [2,X1]. From this we can derive a linear mapping that will rotate vectors in $\mathbb{R}^3$, about any arbitrary axis$\Delta_{\theta\phi\beta}$. See figure 2.

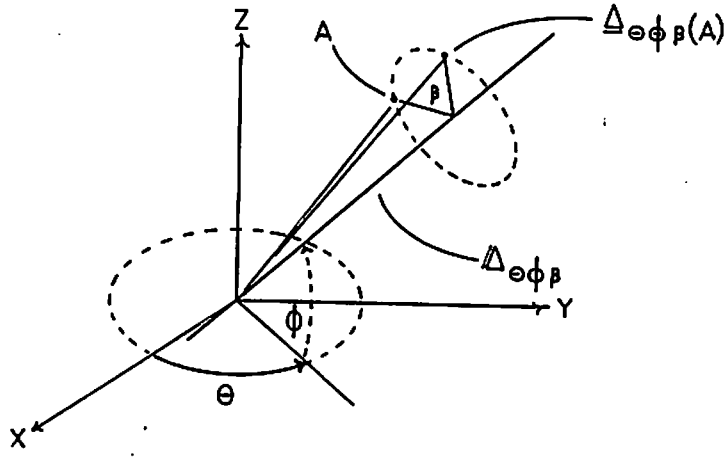


Figure 2

Let $\underline{\Delta}_{\theta\phi\beta}$ denote such a mapping. Then $\Delta_{\theta\phi B}$ can be written as the composition of the $X_\theta, Y_\theta, Z_\theta$ linear mappings. Therefore $\underline{\Delta}_{\theta\phi\beta} = Z_\theta Y_\phi X_\beta \underline{Y}_\phi \underline{Z}_\theta$. Let $\underline{\Delta}_{\theta_i\phi_i\beta_i}$ denote the matrix of the i th rotation in the sequence of rotations Δ. We will let $\underline{\Delta}$ denote the composition of all the $\underline{\Delta}_{\theta_i\phi_i\beta_i}$. Then $\underline{\Delta} = \underline{\Delta}_{\theta\phi\beta}\ \underline{\Delta}_{\theta\phi\beta n-1} \cdot \cdot \cdot \cdot \cdot \underline{\Delta}_{\theta\phi\beta 1}$. Our goal is to find out if there exist two distinct vectors a and b such that

$$a = (\Delta_{\theta\phi\beta_n} \quad \Delta_{\theta\phi\beta_{n-1}} \cdot \cdot \cdot \cdot \Delta_{\theta\phi\beta_1})a$$

$$b = (\Delta_{\theta\phi\beta_n} \quad \Delta_{\theta\phi\beta_{n-1}} \cdot \cdot \cdot \cdot \Delta_{\theta\phi\beta_1})b$$

This would indicate that $\bar{P}$ and $\bar{Q}$ exist. This is the same as finding $a = \underline{\Delta}a$ and $b = \underline{\Delta}b$. Therefore we need to concentrate on the characteristics of Δ.

An isometry of $\mathbb{R}^n$ is a map $f:\mathbb{R}^n \longrightarrow \mathbb{R}^n$ that preserves distances. Thus $f:\mathbb{R}^n \longrightarrow \mathbb{R}^n$ is an isometry if $||f(b) - b(a)|| = ||b - a||$ for all a and b in $\mathbb{R}^n$. [1,299]

Theorem 1 Composition of Isometries

Suppose f and g are two isometries of $\mathbb{R}^n$. Then the map g of $:\mathbb{R}^n \longrightarrow \mathbb{R}^n$ is also an isometry. [1,301]

An isometry that is also a linear map is called a linear isometry.

Theorem 2 Linear Isometries

Let f be a linear isometry of $\mathbb{R}^3$. Then f is either a rotation (if det f>0) or a rotation followed by a reflection (is det f<0). [1,307]

Each $\underline{\Delta}_{\theta_i\phi_i\beta_i}$ is a linear isometry. By theorem 1, $\underline{\Delta}$ is also a linear isometry. Also notice that $\det(\underline{\Delta}_{\theta_i\phi_i\beta_i}) = \det(Z_{\theta_i} Y_{\phi_i} X_{\beta_i} \underline{Y} \underline{\phi_i} \underline{Z} \theta_i) = 1$, and therefore

$\det(\underline{\Delta}) = 1$. By theorem 2, $\underline{\Delta}$ is a rotation about some axis. $\underline{\Delta}$ is the compositon of all the $\underline{\Delta}_{\theta_i\phi_i\beta_i}$. $\underline{\Delta}$ will take the sphere from its initial position to its final position in one step. Since $\underline{\Delta}$ is a rotation, then $\bar{P}$ and $\bar{Q}$ are the points on the axis of this rotation that intersect the sphere. For an example, look at figure 3.

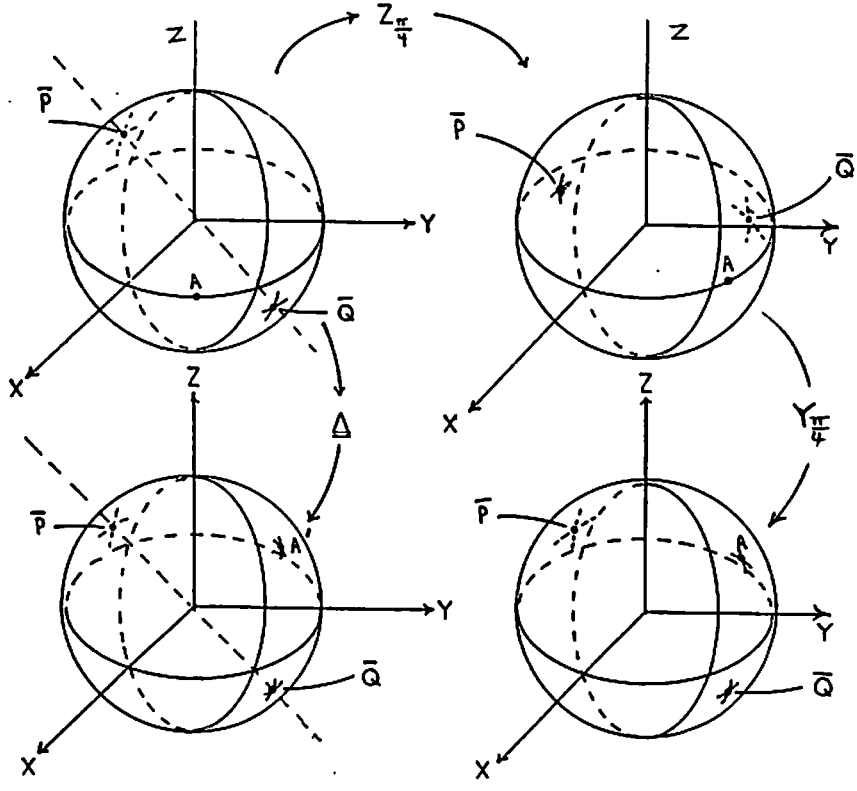


Figure 3

With the help of linear mappings and two isometry theorems, we are able to prove quite easily that the hypothesis about the rotation of a sphere is valid. Unfortunately, to find $\bar{P}$ and $\bar{Q}$, one must know what $\underline{\Delta}$ is and this requires computing the products of all the matrices in the Δ sequence. We know that $\underline{\Delta}$ is a 3x3 matrix and the characteristic polynomial of $\underline{\Delta}$ has degree 3 and so must have at least one real zero. $\underline{\Delta}$ must have at least one eigenvalue. Since we know that $\underline{\Delta}$ is a rotation, λ must be 1. By solving the system $(\underline{\Delta} - I) = \bar{0}$, you will arrive at an eigenspace of dimension 1. [3,237]. This eigenspace is the axis of rotation for Δ and the intersection of this eigenspace and the sphere are the points $\bar{\pi}$ and $\bar{Q}$. The only exception to this occurs when $\underline{\Delta}$ turns out to be the identity matrix I. If this happens then we can conclude that $\bar{P}$ and $\bar{Q}$ are any two points on the surface of the sphere.

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THE PROBLEM CORNER

EDITED BY KENNETH M. WILKE

The Problem Corner invites questions of interest to undergraduate students. As a rule the solution should not demand any tools beyond calculus. Although new problems are preferred, old ones of particular interest or charm are welcome, provided the source is given. Solutions should accompany problems submitted for publication. Solutions of the following problems should be submitted on separate sheets before 1 January 1989. Solutions received after the publication deadline will be considered also until the time when copy is prepared for publication. The solutions will be published in the Spring, 1989 issue of The Pentagon, with credit being given to student solutions. Affirmation of student status and school should be included with solutions. Address all communications to Kenneth M. Wilke, Department of Mathematics, 275 Morgan Hall, Washburn University, Topeka, Kansas 66621.

PROBLEMS 410-413, SOLUTIONS 400, 402-405

Corrected Problem 403: Proposed by the editor.

Young Eulcid pondered a triangle in which one side is 12 feet longer than another. The angle formed by these two sides is 55°. If two circles are drawn with these respective sides as diameters, one of the points of intersection of the circles is the common vertex where these two sides meet. What is the locus of the other point of intersection?

Problem 410: Proposed by the editor.

Let A, G, and H be the arithmetic mean, the goemetric mean and the harmonic mean respectively of the divisors of an even perfect number. Prove or disprove that $G^2 = A \cdot H$.

Problem 411: Proposed by Dmitry P. Mavlo, Moscow, USSR.

Let a, b, and c be positive real numbers and let k be a positive integer. Prove the following inequality and determine all cases when equality occurs:

$$(a + b + c)^k - (a^k + b^k + c^k) \geq [3^k - 3] (abc)^{k/3} .$$

Problem 412: Proposed by the editor.

Fred and Pete were duck hunting one day when a lone mallard flew by within range. Pete is three times more likely to hit his target than Fred is. Assuming that the duck has an even chance to survive, what are Pete and Fred's respective probabilities of hitting the duck?

Problem 413: Proposed by the editor.

While studying the function $F(n) = n! + n^2 - 1$ where n is a positive integer with his computer, a student noticed that F(n) is prime when n = 2. Unfortunately the precision of his computer limits the number of cases in which he can accurately produce a value for F(n). He would like to know other values of n for which F(n) is prime. Find other values of n for which F(n) is prime or show that none exist.

Problem 400: Proposed by the editor.

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

Solution by the proposer.

The given ellipse is shown in Figure 1 below where a = 16 and b = 12. Fred produced the desired curve by dissecting the ellipse and rearranging the parts as shown in Figure 2. This problem is similar to problem 28 which appears in One Hundred Problems in Elementary Mathematics by Hugo Steinhaus, Dover Publications Inc. reprint, 1979, at pp. 18, 87-88. This fine problem was chosen for its unusual solution based upon geometric dissection. The book also gives an alternate solution based upon geometric distortion.

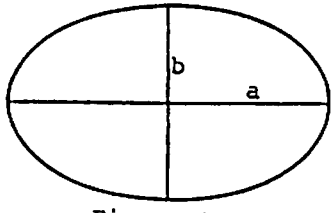


Figure 1

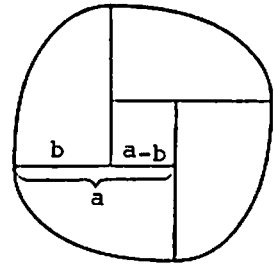


Figure 2

Problem 402: Proposed by the editor.

Evaluate the product

$$\prod_{k=1}^{n} \cos \frac{k\pi}{2n+1}$$

Since no solution has been received for this problem, it will remain open until the next issue at which time a solution will be given if none has been received. A comment has been received which will be held until the next issue also.

Corrected Problem 403: Proposed by the editor.

Young Eulcid pondered a triangle in which one side is 12 feet longer than another. The angle formed by these two sides is 55°. If two circles are drawn with these respective sides as diameters, one of the points of intersection of the circles is the common vertex where these two sides meet. What is the locus of the other point of intersection?

Problem 404: Proposed by the editor.

A certain number N is the product of three primes. If the sum of the cubes of these primes is 2645187 and if the sum of the divisors of N (including N and 1) is 104328, identify the three primes.

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

Let $N = p_1p_2p_3$ where p_1, p_2 and p_3 are distinct primes. Without loss of generality, we may assume that $p_1 < p_2 < p_3$. Also $\Theta(N) = (1 + p_1)(1 + p_2)(1 + p_3) = 104328 = 2^3 \cdot 3^3 \cdot 7 \cdot 23$ where $\Theta(N)$ denotes the sum of the positive divisors of N. Clearly p_2 and p_3 are both odd primes.

If $p_1 = 2$, then we must have

$$2^3 \quad 3^3 \quad 7 \quad 23 = (1 + p_2)(1 + p_3)$$

where one of the factors on the left is divisible by 2 and the other is divisible by 4. The only possibility of this type is

(1) $(1 + p_1)(1 + p_2)(1 + p_3) = (1 + 2)(1 + 11)(1 + 2897)$.

If $p_1 = 2$, each of the factors $1 + p_1$, $1 + p_2$ and $1 + p_3$ must be divisible by 2 but not by 4. The possibilities of this kind are

(2) $(1 + p_1)(1 + p_2)(1 + p_3) = (1 + 13)(1 + 53)(1 + 137)$ and

(3) $(1 + p_1)(1 + p_2)(1 + p_3) = (1 + 17)(1 + 41)(1 + 137)$.

Neither $2^3 + 11^3 + 2897^3$ nor $13^3 + 53^3 + 137^3$ equals 2645187. Since $17^3 + 41^3 + 137^3 = 2645187$, the desired primes are 17, 41 and 137.

Also solved by Keith E. Smith, Mount Mercy College, Cedar Rapids, Iowa.

Editor's Comment: Our featured solver notes that $17^3 + 41^3 + 137^3$ is the only way that 2645187 can be expressed as the sum of the cubes of three positive integers x, y and z with x y z.

Also an alternate approach to the solution would be to note that none of the desired primes can exceed $139 > \sqrt[3]{2645187}$. Then since one of the factors $(1 + p_i)$ is divisible by 23, the only prime of the form 23K - 1 in the required range is 137. Hence $p_3 = 137$. Similar considerations produce the same solution found above.

Problem 405: Proposed by John A. Winterink, Albuquerque, New Mexico.

In triangle ABC, AB = 25, points D and E lie on AC and BC respectively, and DE = 26. Let AD : DC = 1 : 2 and BE : EC = 1 : 6. Determine the smallest integer values for AD and BE such that AB + BC + CA $\underline{<}$ 190.

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

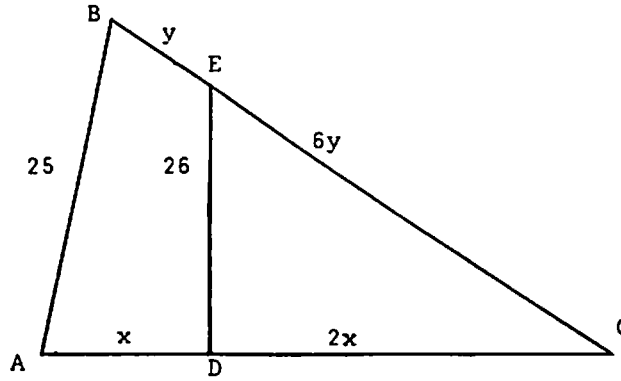
Let AD = x, DC = 2x, BE = y and EC = 6y as shown in the figure below. Then by the Law of Cosines we have

$$(26)^2 = (2x)^2 + (6y)^2 - 2\cdot 2x\cdot 6y\cdot \cos C \qquad (1)$$

and $$(25)^2 = (3x)^2 + (7y)^2 - 2\cdot 3x\cdot 7y\cdot \cos C \qquad (2)$$

which combine to yield the single equation

$$x^2 = 7y^2 - 279 \qquad (3).$$



Figure

The first few solutions of (3) are given by (x,y) = (8,7), (13,8), (27,12), (36,15), (64,25) and (83,32). Then AB + AC + BC = 3x + 7y + 25. Corresponding to the solutions given, we find (x,y,3x + 7y + 25) = (8,7,98), (13,8,120), (27,12,190), (36,15,238), (64,25,392) and (83,32,498) respectively. Since all further solutions of equation (3) involve increasing values of x and y, the corresponding solutions in x and y are x = 8 and y = 7 with AC = 24 and BC = 49; x = 13 and y = 8 with AC = 39 and BC = 56 and x = 27 and y = 12 with AC = 81 and BC = 84. Of these, the desired solution with the smallest values of x and y is x = 8 and y = 7 with AC = 24 and BC = 49. Also solved by the proposer.

THE CURSOR
Edited by Jim Calhoun

The topics presented in this department of THE PENTAGON can be classified as belonging to computer science but their emphasis is more narrowly defined. Like most applied sciences, computer science depends heavily upon a large body of mathematical theory. It is the aim of this department to present discussions which help to define the interface between these two disciplines. Specifically, it seeks to relate ideas from the theory of mathematics to an understanding of concepts in computer science. Readers, particularly students, are encouraged to submit articles on any topic directed toward this goal.

AN APPLICATION OF THE NEWTON-RAPHSON METHOD

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Introduction

In simulation, the generation of a random variate is often needed. For example, in studying arrivals at an airport, one might like to simulate the random variable X which represents time between arrivals of airplanes. In order to achieve this, the inverse distribution function is often used. More specifically if X has a density function f(x), we define

$$F(x) = \int_{-\infty}^{x} f(t)dt.$$

Obtaining a random number R, $0 < R < 1$, by use of a computer random number generator, the solution to

$$R = F(x)$$

must be obtained. Such a solution is considered a random variate. The objective of this paper is to consider the solving of such an equation. It should be observed that in a particular simulation, hundreds of these equations may occur since each random variate generated requires the solving of such an equation. Thus speed of computation is a factor.

Examples

If a random variable X has either of the two following density functions, the equations can be readily solved.

Standard Uniform

$$f(x) = 1 \ , \ 0 < x < 1$$

Implies $R = F(x) = x$ Implies $x = R$.

Exponential

$$f(x) = \frac{1}{\lambda} e^{-x/\lambda} \ , \ x > 0$$

Implies $R = F(x) = 1 - e^{-x/\lambda}$ Implies $x = -\lambda \ \ln(1 - R)$

where it should be observed that $E(X) = \lambda$. In studying time between arrivals of

airplanes as mentioned earlier, the exponential distribution is often assumed.

However a more interesting example involves the chi-square distribution with 4 degrees of freedom (4df) where

$$f(x) = 0.25 \ x e^{-x/2} \ , \ x >= 0$$

Implies solving $R = F(x) = 1 - e^{-x/2} (x/2 + 1), \ x >= 0.$

Discussion of solution of R = F(x) where F = chi-square distribution function with 4 df.

The solution of this equation requires an approximation technique such as the Newton-Raphson method. When the Newton-Raphson method works, it is very fast. However, a close initial guess is very important if one hopes to obtain a sequence that converges to a root of the equation. It is noted that

$F(14) = 0.992$, $\lim_{x \to \infty} F(x) = 1$, F is an increasing function and range of $F(x) = [0,1)$.

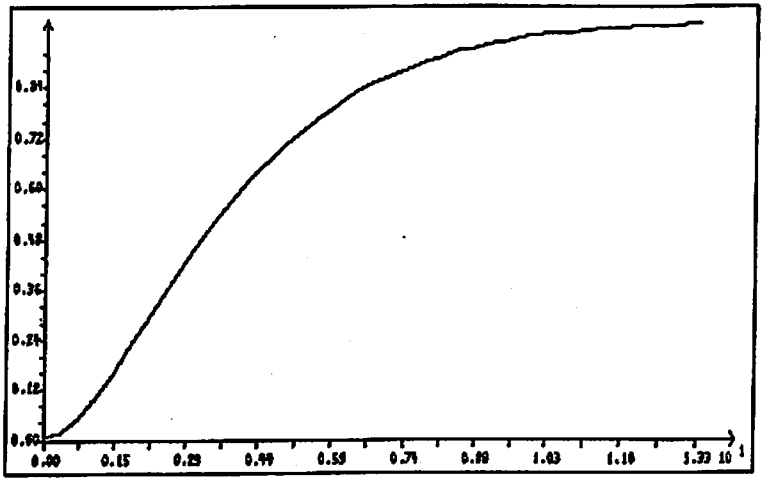
Noting $0 < R < 1$, $R = F(x)$ has a solution. Moreover $E(X)$ = degrees of freedom = 4 implies that perhaps a first guess of 4 might be good, and the solution will lie in [0,14] over 99% of the time.

The table below indicates the results as R varies.

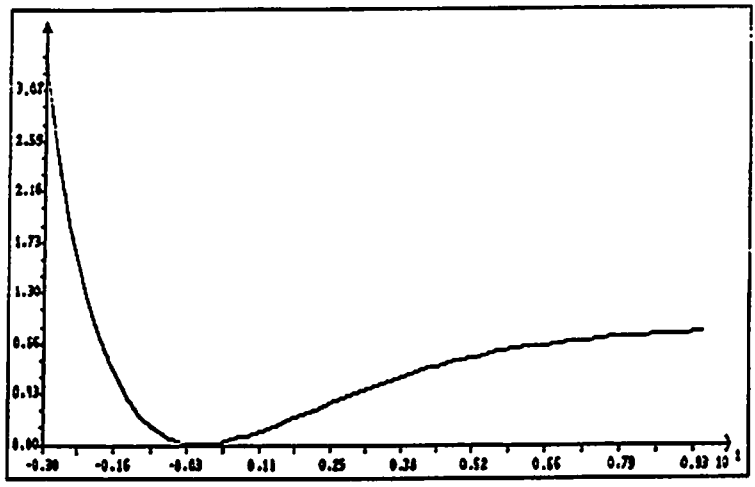
Random Number R	Solution F(x) = R	No Req. Iterations
0.2713013	2.0383840	3
0.0508423	-0.5784991	16
0.9755249	11.1912200	5
0.9912720	13.5866800	6
0.3002319	2.1959640	3
0.0551758	Overflow	
0.0490723	-0.5693868	11
0.1962891	1.6283610	3

Analysis of the Table

The number of iterations seem rather large for some choices of R. So perhaps a better first guess can be found. Moreover, why is a negative solution indicated since F is only defined for x >= 0?
The two sketches below indicate why a negative solution was obtained.



$F(x) = 1 - e^{-x/2}(x/2 + 1)$ for $x \geq 0$ which is the Chi-Square Distribution Function with 4 degrees of freedom



$$\hat{F}(x) = 1 - e^{-x/2}(x/2 + 1) \text{ for all real } x.$$

From the above figure, 2 solutions actually exist if the domain of F is extended to all real numbers. Since

$$\lim_{x \to -\infty} \hat{F}(x) = \infty \quad ,$$

the overflow condition is understandable. So in summary, since only a non-negative solution is acceptable, a better first guess is needed.

Improving on the Initial Guess

Partitioning (0,F(14)) into the intervals ((F(0) ,F(0.5)), [F(0.5) ,F(1.0)), ..., [F(13.0),F(13.5)), [F(13.5),F(14))] assures us statistically that for 0 < R < 1, R will belong to one of the intervals over 99% of the time. For the purposes of simulation, this suffices since if R > F(14), we simply let the random variate x be 14. Now we are ready to improve on our initial guess. For example, if for a given R, F(10) <= R < F(10.5), let the initial guess = 10.5. In repeated computer runs, not only does the Newton-Raphson method converge, it converges more rapidly than with a guess = E(X) = 4. Of course searching the 29 intervals to see which interval contains R is time consuming. Rather than searching using the concept of a sequential search, that is, searching the intervals from left to right as listed above, the use of a binary search as in (Stubbs and Webre) is much faster, thereby saving computer time.

Conclusions

If one tries solving R = F(x) where F is the standard normal distribution function, problems arise since F cannot be written in closed form. However, one can still use the Newton-Raphson method although the evaluation of F(x) at each iteration requires the approximation of an integral. Using Simpson's Rule works satisfactorily except that due to the large number of computations, the whole process is so very slow.

However, the previously discussed solution of R = F(x) for the Chi-Square case is fairly rapid usually requiring fewer than three iterations. In actual practice, one approximates F, the distribution function, with a function P consisting of straight line segments joining certain points of F where the points are chosen so that P provides a good approximation to F. The inverse of P is easily found once P is obtained. Moreover
P can be used instead of approximating F by Simpson's rule as mentioned earlier. Also, the inverse of P is used to generate the random variates.

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KAPPA MU EPSILON NEWS

Edited by M. Michael Awad

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

CHAPTER NEWS

Alabama Beta, University of North Alabama, Florence
Chapter President – Alan Cantrell
32 actives, 18 initiates

Other 1987–88 officers: Jeanne Richardson, vice president; Wade Pulley, secretary; Eddy Joe Brackin, corresponding secretary; Patricia Roden, faculty sponsor.

Alabama Gamma, University of Montevallo, Montevallo
Chapter President – Julie Johnston
11 actives

Other 1987–88 officers: Nancy Harley, vice president; Karen Ulch, secretary; Ron Lagrone, treasurer; Joseph Cardone, corresponding secretary; Angela Hernandez, faculty sponsor.

California Gamma, California Polytechnic State University, San Luis Obispo
Chapter President – Erik Harder
40 actives, 12 initiates

The Chapter assisted the Mathematics Department with the annual Phone–a–thon to raise funds for the School of Science and Mathematics. Weekly meetings featured alumni and industry speakers, including representatives from IBM, USAF, Varian, American Management Systems, Fair Isaac. Several officers' meetings were held to prepare and analyze the results of a questionnaire to determine membership needs with regard to invited speakers, social activities, etc. Five KME members were recommended to the Mathematics Department to receive paid membership in the Mathematical Association of America (MAA). The fall, 1987, quarter

concluded with the Pledge Induction Ceremony and wrapping of Christmas presents for local senior citizens. Other 1987–88 officers: Rex McAfee and Stefan Steiner, 1st vice presidents; Janet Garrett, Dave Martin and Eddie Soliman, 2nd vice presidents; Christine Pohlmeyer and Donald Priest, pledgemasters; Kelly Abbott, treasurer; Susan Daijo, secretary; Chris Denison, Eric Ferrari and Forrest Tanaka, publicity representatives; Teresa Bly and Joni Otoshi, social coordinators; Christine Monts and Dave Orth, alumni representatives; Denise Tobias, School Council representative; Kevin Hathaway, Poly Royal representative; John Coblenz, Curriculum Committee representative; Adelaide Harmon–Elliott, faculty sponsor; Raymond D. Terry, corresponding secretary.

Colorado Gamma, Fort Lewis College, Durango
Chapter President – Johnny Snyder
23 actives, 5 initiates

An initiation ceremony was held in November, 1987. KME members participated in the College Allumni Phone–a–thon and raised $275 for the Chapter. The Chapter continued its weekly high school tutoring sessions. Other 1987–88 officers: Brian Sherfey, vice president; Amy Getz, secretary; Kevin Marushack, treasurer; Richard A. Gibbs, corresponding secretary and faculty sponsor.

Florida Beta, Florida Southern College, Lakeland
Chapter President – Jennifer Page
17 actives

We held several meetings throughout the semester and sponsored a trip to the IBM facilities in Tampa. The trip was very interesting. The IBM personnel were quite friendly and willing to share their job experiences with us. Other 1987–88 officers: Dawn Gallant, vice president; Randi Burnett, secretary and treasurer; Henry Hartje, corresponding secretary and faculty sponsor.

Georgia Alpha, West Geirgia College, Carrollton
Chapter President – Tammy Gresham
28 actives

On October 15, 1987, we met and discussed a Fall Social which was held on November 17, 1987, at 8:00 PM in one of the local steak restaurants.

There were seventeen present, counting members and guests. A good time was had by all. Other 1987–88 officers: David Abeita, vice president; Keisha Cantrell, secretary; Kristi Milam, treasurer; Joe Sharp, corresponding secretary and faculty sponsor.

Illinois Beta, Eastern Illinois University, Charleston
Chapter President – Tricia Setzke

During the course of the fall, 1987, semester we held a number of meetings, had a fall picnic in September, a Halloween Party on October 28, and a Christmas Party on December 4. Other 1987–88 officers: David Wasser, vice president; Dorothy Graham, secretary; Debra English, treasurer; Lloyd Koontz, corresponding secretary and faculty sponsor; Grant Alexander, faculty sponsor.

Illinois Delta, College of St. Francis, Joliet
Chapter President – Jeanette Rogers

Our fall meeting featured Sharon Mannlein, actuarial consultant and President of S. K. Mannlein and Associates, Downers Grove, Illinois. The meeting was open to all students at the College of St. Francis. Other 1987–88 officers: Pamela Damore, vice president; Jo Ann Lopykinski, secretary; Peter Kohl, treasurer; Sister Virginia McGee, corresponding secretary and faculty sponsor.

Illinois Zeta, Rosary College, River Forest
Chapter President – Patricia Cava
17 actives, 6 initiates

Our first meeting was held on September 22nd: New officers were introduced, the new attendance policy was explained, new ideas were discussed concerning raising more money for our Chapter. Three more meetings were held during the semester. The induction of new members took place on November 24, 1987. Our KME Christmas Dinner took place at Giordano's on December 17, 1987. Other 1987–88 officers: Natalie Perri, vice president; Mariola Janek, secretary; Kathy Schmidt, treasurer; Mordechai Goodman, corresponding secretary and faculty sponsor.

Illinois Theta, Illinois Benedictine College, Lisle
Chapter President – Jacqueline Haeflinger
12 actives, 4 initiates

Our first meeting of the semester was held on September 15. Our Tutor List was organized to help students with their Math studies. We announced our Math Challenge – Bimonthly we printed a math problem in our school newspaper challenging students to solve the problem and submit their solution. September 28 – October 2: Annual Airhead Balloon Sale to celebrate Homecoming. October 2: Sponsored a booth at the Homecoming Carnival. On October 13 we held our second meeting and began selling sweatshirts with our school crest on them. A number of other events took place during the semester, including a volleyball game against Tri–Beta on October 19; the induction of four new members into KME on November 4; a Reindeer Candy Cane Sale November 30 through December 3; and our Christmas Pizza Party on December 6. Other 1987–88 officers: Paul Toussaint, vice president; Tracey Ulanski, secretary; Jill Vognar, treasurer; James Meehan ,corresponding secretary and faculty sponsor.

Indiana Alpha, Manchester College, N. Manchester
Chapter President – Dawn Crum
20 actives

Our Chapter sponsored a fall picnic held on October 4 for all students interested in mathematics and computer science. On October 27, Dr. Weber (Miami University) gave an address on "Probability, Statistics, and the Law." Professor Rowe (Manchester College) gave a presentation on "Chess on a Torus" on November 10. On December 13, we joined with other science organizations for a holiday party and demonstration of soap bubble behavior by Dr. Dwight Farringer (Manchester College). Other 1987–88 officers: Verne Leininger, vice president; Julie Eichenauer, secretary; Daniel Byler, treasurer; Ralph McBride, corresponding secretary; Deborah Hustin, faculty sponsor.

Indiana Delta, University of Evansville, Evansville
Chapter President – Lisa Maikranz
31 actives

Ms. Lisa Maikranz, Dr. Mohammad K. Azarian, and Dr. James Vinson were the speakers for the fall meetings. Also, the Chapter sponsored an undergraduate mathematics contest. Other 1987–88 officers: David

Cantrell, vice president; Shannon Fuhrman, secretary; Melba Patberg, corresponding secretary; Mohammad K. Azarian, faculty sponsor.

Iowa Alpha, University of Northern Iowa, Cedar Falls
Chapter President – Diane Strechan
32 actives, 8 initiates

On October 3, 1987, the annual KME homecoming breakfast was absorbed by the College of Natural Science all–year–homecoming events. The invitation extended by Iowa Alpha to host a Region IV convention was accepted and April 23, 1988, has been selected as the date. Students presenting papers at local KME meetings include: Bob Hauser on "The Temperature in a Cube," Greg Mehrl on "The Equation of the Ellipse," and Suzanne Buckwalter on "The Hyper Reals." Kerris Renken gave the address at the KME initiation banquet on December 7, speaking on "The Negative Binomial Distribution." Because of student teaching commitments for spring semester, 1988, Robert Hauser will replace Diane Strechan as president of Iowa Alpha and Joseph Inman was elected to the office of vice president. Other 1987–88 officers: Robert Hauser, vice president; Greg Mehrl, treasurer; Suzanne Buckwalter, treasurer; John S. Cross, corresponding secretary and faculty sponsor.

Iowa Delta, Wartburg College, Waverly
Chapter President – Susan Poppen
42 actives

Monthly meetings this fall have featured presentations about recent internships, career opportunities in mathematics and skits about historical "math moments." The Chapter money–maker was selling egg–cheese sandwiches (a special "memory–trip" treat for alumni) at the Renaissance Faire event of the Wartburg College Homecoming. Other 1987–88 officers: Candy Saunders, vice president; Terry Letsche, secretary; Brian Isaacs, treasurer; August W. Waltmann, corresponding secretary; Lynn J. Olson, faculty sponsor.

Kansas Alpha, Pittsburg State University, Pittsburg
Chapter President – Darbi (Frieden) Stancell
50 actives, 8 initiates

The Chapter held monthly meetings in October, November, and

December. In addition, a fall picnic was hosted for all mathematics and physics students. Fall initiation for new members was held at the October meeting. Eight new members were initiated at that time. This meeting was preceded by a pizza party. The October program was given by Mr. Merle Leech, PSU Art Department faculty member. His topic was Mathematics in Art. Pat Robertson and Scott Sesher presented the November program on "Least Squares Analysis." In December, a special Christmas meeting was held at the home of Dr. Helen Kriegsman, Mathematics Department Chairperson. Marcia Allmond gave the program entitled "The Theory of Stakes."

Kansas Beta, Emporia State University, Emporia
Chapter President – Deanne Eberhart
26 actives, 11 initiates

The normal monthly meetings were held during the fall semester. Our Initiation Banquet speaker was Dr. Essam Abotteen. Other 1987–88 officers: Stephanie Payne, vice president; Charles Fennel, secretary; Doris Prothe, treasurer; George L. Downing, corresponding secretary; Larry Scott, faculty sponsor.

Kansas Gamma, Benedictine College, Atchison
Chapter President – Lisa Brox
17 actives, 8 initiates

Other 1987–88 officers: Susanne Piper, vice president; Elizabeth Zahrt, secretary and treasurer; Richard Farrell, corrsponding secretary; Sister JoAnn Fellin, faculty sponsor.

Kansas Epsilon, Fort Hays State University, Hays
Chapter President – Marty Orth
5 initiates

Among the fall semester events: monthly meetings, fall picnic, Christmas Party. Other 1987–88 officers: Roger Schuster, vice president; Tom Albers, secretary and treasurer; Charles Votaw, corresponding secretary; Mary Kay Schippers, faculty sponsor.

Kansas Delta, Washburn University, Topeka
Chapter President – Kelly Eisenbarth
15 actives

We invited interested mathematics students to a KME meeting with the idea of forming a mathematics club for students not eligible for KME. Also, we began planning for the biennial national meeting to be held at Washburn on April 6–8, 1989. Other 1987–88 officers: Kara Richey, vice president; Jill Rasmussen, secretary and treasurer; Robert H. Thompson, corresponding secretary; Ron Wasserstein, faculty sponsor.

Kentucky Alpha, Eastern Kentucky University, Richmond
Chapter President – Brenda Coble
23 actives

In keeping with tradition, the fall semester started with a picnic at the Costello's house with the incoming majors in the Department invited to join in the fun. A Big Brother/Big Sister program was started to try to help the incoming majors get used to the school and to inform them of KME activities. In October ten students participated in the Virginia Tech Regional Mathematics Competition with several doing quite well. In December Teresa Snowden from Sherwin–Williams came and spoke to us about "Statistical Process Control." Besides being a good speaker, Teresa brought Sherwin–Williams paint hats for everyone. The final activity of the semester was a Christmas party the week before finals. Other 1987–88 officers: Don Steinberg, vice president; Carrie Lash, secretary; Dave Boldery, treasurer; Pat Costello, corresponding secretary; Bill Janeway, faculty sponsor.

Maryland Delta, Frostburg State University, Frostburg
Chapter President – Bradley Richards
22 actives

The fall activities of Maryland Delta Chapter opened with a picnic at Rocky Gap State Park. In October the group sponsored a talk by Dr. Edward White entitled, "Graphing with the IBM–PC: A Home–Grown Program," and in November a talk by Dr. Marcelle Bessman on "Sonya Kovalevsky: Woman of Mathematics." A successful fund–raising raffle was held in December. Other 1987–88 officers: Lisa Lewis, vice president; Laura Dudley, secretary; Judy Anderson, treasurer; Edward T. White, corresponding secretary; John Jones, faculty sponsor.

Maryland Beta, Western Maryland College, Westminster
Chapter President – Daniel Seabold
15 actives, 3 initiates

Other 1987–88 officers: Andrew Raith, vice president; Mary Beth VanPelt, secretary; Christopher Sawicki, treasurer; James E. Lightner, corresponding secretary; Linda R. Eshleman, faculty sponsor.

Michigan Beta, Central Michigan University, Mt. Pleasant
Chapter President – Mark Longman
40 actives – 27 initiates

At the first fall meeting, KME invited any mathematics students who were interested in mathematics and/or KME. The mathematics chairperson, Richard Fleming, spoke. He talked about the discipline of mathematics – its logical development, its beauty, its application, and the pride students should take in being participants with the subject. Many of those in attendance were eventually initiated later in the semester. The attractive KME banner made by the California Gamma Chapter and shown at the 1987 National Convention prompted some of our members to make a banner. It is made out of felt and is a replica of the KME plaque. Janice Wade is to be congratulated for her fine work on the banner. A highlight of fall, 1987, was the hosting of a retirement banquet for two mathematics professors, Wilbur Waggoner and Edward Whitmore. Professor Whitmore was previously Chairperson of the Department and very supportive of KME. Professor Waggoner has been very active at the national level of KME. The banquet was held in conjunction with our fall initiation. Many KME alumni attended along with faculty and members. Our guest speaker at a November meeting was Bob Kasprzyk. He is a statistician at Dow Chemical in Midland and he talked on the career of a statistician. We finished the fall semester with a Christmas party at the home of our advisor, Arnold Hammel, and family. Plans are underway to have teams of KMEers playing campus recreation co–ed basketball and volleyball. Other 1987–88 officers: Brian Varney, vice president; Amy Scheuerman, secretary; Nancy Haskell, treasurer; Arnold Hammel, corresponding secretary and faculty sponsor.

Mississippi Alpha, Mississippi University for Women, Columbus
Chapter President – Katherine M. Adams
7 actives, 10 initiates

The Mississippi Alpha Chapter sponsored a seminar this fall for the

Division of Science and Mathematics. Dr. Lida Barrett, President–Elect of MAA, spoke on "Applied Mathematics and Changes in Calculus." Other 1987–88 officers: Michelle Whitley, vice president; Sherri Duncan, secretary and treasurer; Jean A. Parra, corresponding secretary; Carol B. Ottinger, faculty sponsor.

Mississippi Gamma, University of Southern Mississippi, Hattiesburg
Chapter President – Sandra Kloske
28 actives, 12 initiates

Over three hundred teachers met at the University of Southern Mississippi on September 18 and 19 for the Mississippi Council of Teachers of Mathematics annual meeting, at what was termed by all as the "biggest and best meeting ever!" Dr. Nancy Dunigan thought of the theme of the conference and buttons and tee–shirts with this theme were sold to benefit MCTM. The theme "My Heart Belongs To Math!" was imprinted onto the polar coordinate graph "$r = 1 + \cos \theta$." MCTM and KME members stayed busy trying to keep up with the demand for these items. Our Chapter also held its fall initiation and supper on October 29 at the home of Dr. and Mrs. Robert King. Other 1987–88 officers: Sherri McMullan, vice president; Joyce Deer, secretary and treasurer; Alice Essary, corresponding secretary; Virginia Entrekin, faculty sponsor.

Missouri Alpha, Southwest Missouri State University, Springfield
Chapter President – Kevin Keltner
31 actives, 5 initiates

During the fall of 1987, Missouri Alpha held two regular meetings, a picnic and one joint meeting with Missouri Kappa and Missouri Theta, hosted by Missouri Theta at Drury College. Other 1987–88 officers: Anita Shockley, vice president; Sherri Renegar, secretary; Sharon Kruse, treasurer; John Kubicek, corresponding secretary; Simon Bernau, faculty sponsor.

Missouri Beta, Central Missouri State University, Warrensburg
Chapter President – David Beard
25 actives, 10 initiates

The Missouri Beta Chapter had three regular meetings during the fall semester. Speakers featured during the meetings were Anna Adamik, Fulbright Scholar from Hungary; Mark Milton, actuary from Kansas City

Life Insurance Company; and Bob Busby, computer programmer from Harmon Industries. The Chapter continued sponsoring the KME Math Clinic which offers free tutoring to math students with time donated by KME members. A book sale was held to offer math books donated to KME by faculty members, and the semester came to a close with a Christmas party. Other 1987–88 officers: Richard Wohlertz, vice president; Gayla Benson, secretary; Kelly Elwell, treasurer; Homer Hampton, corresponding secretary; Larry Dilley, faculty sponsor.

Missouri Gamma, William Jewel College, Liberty
Chapter President – Greg Dance
21 actives

Monthly meetings were held during the fall semester, 1987. Other 1987–88 officers: Laura Kephart, vice president; Susan Brannen, secretary; Joseph T. Mathis, corresponding secretary and faculty sponsor.

Missouri Epsilon, Central Methodist College, Fayette
Chapter President – Lynn Stacy
8 actives

Other 1987–88 officers: Suzie Conley, vice president; Mark Briesacher, secretary and treasurer; William D. McIntosh, corresponding secretary; Linda O. Lembke and William D. McIntosh, faculty sponsors.

Missouri Iota, Missouri Southern State College, Joplin
Chapter President – Melissa Landers
24 actives

The fall semester began with a September canoe trip down Elk River. The organization added $250 to their checking account by working at the MSSC football concession stands. Programs presented at the regular business meetings included: "A Combination Theorem" by Robert Stokes and Julie Stirewalt, a talk by Susan Paulson concerning a problem from the Pentagon and a problem from the 1986 Putnam Exam, and a presentation by Barbara Bentz entitled "The Transportation Problem." A Halloween get–together and the annual Christmas party were held at Mrs. Elick's house. "Win, Lose, or Draw" and "Scruples" were favorite party games. The organization participated in the Christmas window–painting contest sponsored by the MSSC College Activities Board. The following KME

students competed in the 1987 National Putnam Exam: Robert Stokes, Melissa Landers, Susan Paulson, Julie Stirewalt, Julie Millet, and Tom Barkowiak. Other 1987–88 officers: Robert Stokes, vice president; Susan Paulson, secretary and treasurer; Julie Stirewalt, historian; Mary Elick, corresponding secretary; Joe Shields, faculty sponsor.

Missouri Kappa, Drury College, Springfield
Chapter President – Donna Luetkenhaus
5 actives, 5 initiates

The Chapter ran a balance of social, academic, and service activities for the fall semester. The first activity was a bonfire weiner roast held at Dr. Allen's house. The second event was a faculty talk given by Dr. Jim Riley (Physics Department) on "The Wave Equation." The winners of the Annual Campus Math Contest were Larry Fraser – Division 1 (Calculus 1 and below), and Scott Steubing – Division 2 (Calculus 2 and above). Prize money was awarded. The highlight of the semester was a joint meeting with Missouri Alpha (SMSU) and Missouri Theta (Evangel College) held at Drury College. A panel of representatives from each chapter discussed the issues of chapter activities, membership problems, and undergraduate research. The success of the joint meeting was confirmed by the decision to have such a meeting next year. The Chapter continued to run a free Math Tutoring Service for all math students at Drury. Other 1987–88 officers: Missy Arnold, vice president; Christine Hutchison, secretary; Andrea Ehrsam, treasurer; Charles S. Allen, corresponding secretary; Ted Nickle, faculty sponsor.

Nebraska Alpha, Wayne State College
Chapter President – Mike Sieh
24 actives

Throughout the semester club members have monitored the Math–Science Building in the evenings to earn money for the club. In October club members participated in a pre–Parents' Day "all campus clean–up" which was sponsored by the Wayne State College Student Senate. The club participated in the college homecoming activities by painting and erecting a billboard. The billboard won first place in the organizational displays competition. Club members also manned a golf putting booth at the Homecoming Carnival. Chris King was awarded the $25 book scholarship which is given to a KME member each semester by the club. With a grant from the Wayne State College Student Senate, KME and Computer Club purchased an Apple GS computer. Club officers made a fun video of

Mathematics Department instructors, interviewing them in situations to which they were unaccustomed. The video, called Instructors Nightmare, was shown at a regular meeting as entertainment. Social activities this semester included a pizza–movie party at Dr. Paige's home and a Christmas party with a gag–gift exchange. Other 1987–88 officers: Jim Fisher, vice president; Heather Ballard, secretary and treasurer; Michelle Dubas, historian; Fred Webber, corresponding secretary; Jim Paige and Hilbert Johs, faculty sponsors.

Nebraska Gamma, Chadron State College, Chadron
Chapter President – Hortensia Soto
17 actives, 8 initiates

We initiated eight new people. They were Bradley Hicks, Gayle Hurley, Jerry LaBaw, Deborah Nowakowski, Jeffrey Pohl, Kim Sedlacek, Terry Settlemire, and Neamen Tewahade. We also sponsored a convention for NATM in October. We had a good turn–out with lots of teachers from Nebraska coming to the conference. Other 1987–88 officers: Tracy Gifford, vice president; Kathleen Hall, secretary; Bruce Ford, treasurer; James A. Kaus, corresponding secretary; Monty Fickel, faculty sponsor.

Nebraska Delta, Nebraska Wesleyan University, Lincoln
Chapter President – Nicole Austin
16 actives

The Chapter held monthly meetings. Alisa Castillo, a recent graduate, gave a presentation on her experiences working at a financial institution, and job possibilities in that field. We began planning for our High School Math and Computer Contest in the spring. Other 1987–88 officers: Trevor Jares, vice president; Diane Humphrey, secretary; Nancy Nichols, treasurer; Muriel Skoug, corresponding secretary; Daniel Kaiser, faculty sponsor.

New Mexico Alpha, University of New Mexico, Albuquerque
Chapter President – Mohammad Akbarzadeh

We joined with the graduate students in the Mathematics Department in planning a picnic for math majors, KME members, and math faculty and staff. Other 1987–88 officers: Sheryl Henry, vice president; Chris Kaye, secretary; Rachel Vickrey, treasurer; Merle Mitchell, corresponding secretary and faculty sponsor.

New York Alpha, Hofstra University, Hempstead
Chapter President – Susan Genzardi
6 actives, 5 initiates

Other 1987–88 officers: Sandra McGrath, vice president; Johathan Krasner, secretary; Pamela Caplette, treasurer; Stanley Kertzner, corresponding secretary and faculty sponsor.

New York Eta, Niagara University, Niagara
Chapter President – Christina Bonnette
15 actives

We had two meetings in the fall to organize and plan for a speaker during the spring semester. Plans are also going forward for our initiation banquet for new members, which is our big event of the year this spring. The members of our group have also been involved in fund raising activities to raise money for our supplies, etc. Other 1987–88 officers: Suzanne Park, vice president; Melinda Robinson, secretary and treasurer; Robert L. Bailey, corresponding secretary; Kenneth Bernard, faculty sponsor.

New York Kappa, Pace University, New York
Chapter President – Panagiotis N. Nikolakos
30 actives

A Discrete Mathematics seminar was held each Wednesday of the semester. Our induction ceremony and dinner will be held on March 15, 1988. Other 1987–88 officers: Stephanie K. Zielenski, vice president and treasurer; Panagiotis N. Nikolakos, secretary; Louis V. Quintas, corresponding secretary; John W. Kennedy and Martin Kotler, faculty sponsors.

New York Lambda, C. W. Post Center – Long Island University, Greenvale
Chapter President – Louis Sassano
29 actives

Several meetings were held to prepare for the Region I meeting to be held at C. W. Post next spring. Other 1987–88 officers: Jean L. Jerome, vice president; Nancy Portelli, secretary; Ann Marie Esposito, treasurer; Kevin O'Reilly, historian; Andrew M. Rockett, faculty sponsor.

New York Mu, St. Thomas Aquinas College, Sparkill
Chapter President – Anthony Scott
10 actives

Douglass A. White, General Manager for Frequency Planning and Design at NYNEX Mobile Communications, gave a very interesting talk on the evolution of mobile phones and what is the expected future for the mobile communications industry. He also was very helpful in suggesting the best ways to pursue a career in this field for students who were interested in this area. Members of the Chapter gave an excellent presentation, which was open to the faculty and students, on computer graphics. They covered not only the theory behind what the machines do but also covered their use in the classroom and in the business world. Other 1987–88 officers: Dianne Hausner, vice president; Christine DiRienzo, secretary; Joseph DeDona, treasurer; Mary Ellen Ferraro, corresponding secretary and faculty sponsor.

Ohio Alpha, Bowling Green State University, Bowling Green
Chapter President – Carolyn Styer
50 actives

Activities for the semester included a hayride at an area family farm. Also, a special lecture and show in the BGSU Planetarium was presented by Dr. Dale Smith, Director: (1) The lecture was given on the Celestial Coordinate Systems and how the Star Projector displays them. (2) There was a special showing of "It's About Time," a multimedia show produced at BGSU. Other 1987–88 officers: Michelle Mihall, vice president; Beth Natterer, secretary; Todd Hoadley, treasurer; Waldemar Weber, corresponding secretary; Thomas Hern, faculty sponsor.

Ohio Gamma, Baldwin–Wallace College, Berea
Chapter President – John MacDougall
20 actives

Other 1987–88 officers: Lisa Renker, vice president; John Waters, secretary; Tracy Glodziak, treasurer; Robert Schlea, corresponding secretary and faculty sponsor.

Ohio Zeta, Muskingum College, New Concord
Chapter President – Connie Garces
2 initiates

Our initiation of new members was held in October. In November we had guest speakers from Miami University. A popcorn sale was held in December. Other 1987–88 officers: Kevin Dunn, vice president; Gina Alverson, secretary; Tim Coyne, treasurer; Carolyn Crandell, corresponding secretary; Russell Smucker, faculty sponsor.

Oklahoma Alpha, Northeastern Oklahoma State University, Tahlequah
Chapter President – Patricia McGinn
30 actives, 10 initiates

The fall initiation ceremony for ten new members was held in the banquet room of the Western Sizzlin' Steak House in Tahlequah. Other 1987–88 officers: Scott Forester, vice president; Cathy Carlin, secretary and treasurer; Joan E. Bell, corresponding secretary and faculty sponsor.

Oklahoma Gamma, Southwestern Oklahoma State University, Weatherford
Chapter President – Bobby Boyd
20 actives, 18 initiates

Dr. John Jobe from Oklahoma State University gave a talk here this fall. We also held our fall picnic. In December we had a Christmas Pizza Party. Other 1987–88 officers: Allison Roberts, vice president; Kellie Logan, secretary; Lisa Tackett, treasurer; Wayne Hayes, corresponding secretary; Robert Morris, faculty sponsor.

Pennsylvania Alpha, Westminster College, New Wilmington
Chapter President – Karen Haney
24 actives, 3 initiates

Other 1987–88 officers: T. R. Walters, vice president; Theresa Stamos, secretary; Mary Joyce, treasurer; J. Miller Peck, corresponding secretary; Warren Hickman and Fr. George Brunish, faculty sponsors.

Pennsylvania Delta, Marywood College, Scranton
Chapter President – Karen Borusovic
8 actives

Attendance by some members at the Regional National Council of Teachers of Mathematics Conference in Uniondale, New York, December 3–5, 1987. Other 1987–88 officers: Laurie Bartol, vice president; Mary Roginski, secretary; Tom Powell, treasurer; Sr. Robert Ann von Ahnen, corresponding secretary and faculty sponsor.

Pennsylvania Kappa, Holy Family College, Philadelphia
Chapter President – Scott Kromis
10 actives, 5 initiates

The monthly meeting was held every third Thursday of the month. The agenda consisted of discussion of field trips and solutions of various problems prepared by Sister Grace. During the Thanksgiving holidays the members toured the Mint. Also they looked at some of the restored buildings, e.g., the Bonerse Building, the Lits Building, the Reading Terminal, and took note of the architecture, which is outstanding. Many of the members tutored students (without charge) who requested help. Other 1987–88 officers: Eric Mehler, vice president; Constance Hefner, secretary and treasurer; Sister M. Grace, corresponding secretary and faculty sponsor.

Pennsylvania Epsilon, Kutztown University, Kkutztown
Chapter President – Pam Dotterer
7 actives

Other 1987–88 officers: Kevin Olsen, vice president; Glen Naregang, secretary; Chad Benner, treasurer; Cherry C. Mauk, corresponding secretary and faculty sponsor.

Pennsylvania Eta, Grove City College, Grove City
Chapter President – Anne Kister
25 actives, 14 initiates

Fall activities for our Chapter consisted of (1) the fall initiation of new members on October 20, 1987; (2) sponsoring a mathematics professor from Clemson University (10–23–87), who spoke on "Unsolved Problems in Graph

Theory;" and (3) the annual Christmas party on December 8, 1987, at the home of the Math Department Chairman, Mr. Jack Schlossnagel. Other 1987–88 officers: Terri Mauersberg, vice president; Cara Masquelier, secretary; Janet White, treasurer; Marvin C. Henry; corresponding secretary; Dan Dean, faculty sponsor.

Pennsylvanie Theta, Susquehanna University, Selinsgrove
Chapter President – Bill Purnell
11 actives, 2 initiates

Other 1987–88 officers: Kerrie Linker, vice president; Stephen Schneeweis, secretary; James Turner, treasurer; Carol Harrison, corresponding secretary and faculty sponsor.

Pennsylvania Iota, Shippensburg University, Shippensburg
Chapter President – Julie Peterson
6 initiates

Other 1987–88 officers: Sandy Gorka, vice president; Meg Masterson, secretary; Howard Bell, treasurer; Lenny Jones, corresponding secretary; Rick Ruth, faculty sponsor.

Pennsylvania Lambda, Bloomsburg University, Bloomsburg
Chapter President – Michelle Frye
30 actives, 3 initiates

Some fall semester activities: picnic, induction ceremony, fund raiser, preparation for regional convention at C. W. Post University. Other 1987–88 officers: Michael Jarus; Karen Billingham, secretary; Linda Davaillus, treasurer; James Pomfret, corresponding secretary; Joseph Mueller, faculty sponsor.

Pennsylvania Mu, Saint Francis College, Loretto
Chapter President – Aileen O'Brien
12 actives

Other 1987–88 officers: Gene Famigletti, vice president; Karen Kumpon, secretary; Marie Sumner, treasurer; Adrian Baylock, corresponding

secretary.

Pennsylvania Nu, Ursinus College, Collegeville
Chapter President – Tracey Hitchner
20 actives

The Pennsylvania Nu Chapter of KME was installed last April. Consequently this past semester was our first full term as an active chapter. On September 18 we held a reception and "get acquainted" meeting for all interested students and faculty. Our chapter president introduced all of the officers and described KME. The turnout for this event was quite good. Many science majors attended along with faculty from mathematics and physics. Several students were very interested in being considered for membership. On October 19 we organized and held a showing of the NOVA program "A Mathematical Mystery Tour." Pizza and soft drinks were served along with the showing. Funds were obtained from the Student Activities Committee. There were two officers' meetings during the semester where possible activities were discussed. After the second of these we held another open meeting on December 7. Our president took the opportunity to update those present on ideas that had been considered. These include: inviting a speaker for next semesteer, attending a student papers meeting at Moravian College (where two Ursinus math majors are making presentations), formalizing a proposal for modifying the Ursinus math requirement and planning for the MAA regional meeting at Ursinus on April 9, 1988. Finally it is my pleasure to add that the four officers have done an excellent job with our Chapter. They have worked very hard and with great enthusiasm. Thanks to them our Chapter is off to a fine start. Other 1987–88 officers: Gayle Nicosia, vice president; Kimberly Caldwell, secretary; Sandra Dicton, treasurer; Jeff Neslen, corresponding secretary; John Shuck, faculty sponsor.

South Carolina Gamma, Winthrop College, Rock Hill
Chapter President – Martha Atkins
18 actives, 3 initiates

Other 1987–88 officers: Denise L. Nibarger, vice president; Rebecca Turpin, secretary; Cindy Nicholson, treasurer; Donald Aplin, corresponding secretary; Edward Guettler, faculty sponsor.

Tennessee Alpha, Tennessee Technical University, Cookeville
Chapter President – Craig Marrow
25 actives, 46 initiates

During the fall quarter topics such as math graduate schools, infinity, and job hunting were discussed at our meetings. Also a very successful plant trip to Marshall Space Flight Center occurred in November. Other 1987–88 officers: Amy Scott, vice president; Patrick Godin, secretary; Joe Coen, treasurer; Frances Crawford, corresponding secretary; John T. Mason III and Brian O'Connor, faculty sponsors.

Tennessee Delta, Carson–Newman College, Jefferson City
Chapter President – James Day
16 actives

In September a panel discussion on graduate school was presented by three Carson–Newman math alumni. October activities included a hike in the Smoky Mountains and a picnic/volleyball outing to Panther Creek State Park. A Christmas dinner was held at the home of Dr. Vanaman. Other 1987–88 officers: Elizabeth Nations, vice president; Rhonda Neihardt, secretary; Trevor Roberts, treasurer; Albert Myers, corresponding secretary; Carey Herring, faculty sponsor.

Texas Alpha, Texas Tech University, Lubbock
Chapter President – Cathy Cain
25 actives, 15 initiates

Other than regular meetings a reception was held for the fifteen new members. Other 1987–88 officers: Karen Engel, vice president; Gregory Henderson, secretary; Roger Frazier, treasurer; Robert Moreland, corresponding secretary and faculty sponsor.

Texas Beta, Southern Methodist University, Dallas
Chapter President – Abha Singh
50 actives, 5 initiates

The fall semester was spent preparing for our high school math contest this spring. In addition, we have invited a speaker from the Southwest Actuarial Society to our spring induction. Other 1987–88 officers: Veronica

Li, vice president; Behzad Peikari, secretary; Peter Miller, treasurer; Robert Davis, corresponding secretary and faculty sponsor.

Texas Eta, Hardin–Simmons University, Abilene
Chapter President – Susan Petersen
17 actives

A Get–Acquainted Ice Cream Party for all students interested in mathematics was held at the home of Dr. and Mrs. Hewett (Dr. Hewett is a sponsor of KME). The purpose and activities of the society were explained to prospective members. Members inducted in the spring also received their shingles. Other 1987–88 officers: John Dailey, vice president; Kellie Webb, secretary; Rickie Davis, treasurer; Mary Wagner, corresponding secretary; Charles Robinson and Ed Hewett, faculty sponsors.

Texas Iota, McMurry College, Abilene
Chapter President – Hollis Millikin
10 actives

Other 1987–88 officers: Jesus Rodriguez, vice president; Shu–Mei Chen, secretary; Carl A. Piel, Jr., treasurer; Lucille Hodges, corresponding secretary; Bill J. Dulin, faculty sponsor.

Virginia Beta, Radford University, Radford
Chapter President – Mary Margaret Hart
14 actives

Some fall activities: Herta Frietag was invited as a guest speaker. We held weekly math lab (tutoring) sessions sponsored by KME and the Math Club. We held "Meet the Faculty Night" at the beginning of the year. Other 1987–88 officers: Rosemary Oakes, vice president; Linda Potter, secretary; Nancy Hurt, treasurer; Steve Corwin, corresponding secretary; J. D. Hansard, faculty sponsor.

Wisconsin Gamma, University of Wisconsin – Eau Claire, Eau Claire
Chapter President – Karsten Haugen
39 actives, 15 initiates

The 1987 fall semester began with the initiation of 15 new members. Four student presentations were given at the regular meetings during the semester. At Thanksgiving time our vice president hosted a pot luck dinner for students and faculty. The treasury was increased due to a successful popcorn fund–raiser. Since the president and vice president will graduate in December, a special election for two new officers was held at the end of the semester. Steve Poole was elected president and Karen Tallafuss was elected vice president for the spring, 1988, semester. Other 1987–88 officers: Shelly Lundgren, vice president; Kathy Hannar, secretary; John Maierhofer, treasurer; Tom Wineinger, corresponding secretary.

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Papers and problems are needed for

The Cursor (see p. 33), and
The Problem Corner (see p. 26).

Please consider submitting an article or a problem to the appropriate editor.

ANNOUNCEMENT OF TWENTY-SEVENTH BIENNIAL CONVENTION

The 27th Biennial convention of Kappa Mu Epsilon will be held on April 6-8, 1989 at Washburn University, Topeka, Kansas. Each chapter that sends a delegation will be allowed some travel expenses from National Kappa Mu Epsilon funds. Travel funds are disbursed in accordance with Article VI, Section 2 of the KME constitution.

A significant feature of this convention will be the presentation of papers by student members of KME. The mathematics topic which the student selects should be in his/her area of interest, and of such scope that he/she can give it adequate treatment within the time allotted.

Who May Submit Papers? Any student member of KME, undergraduate or graduate, may submit a paper for use on the convention program. A paper may be co-authored; if selected for presentation at the convention it must be presented by one or more of the authors. Graduate students will not comp ete with undergraduates.

Subject: The material should be within the scope of the understanding of undergraduates, preferably those who have completed differential and integral calculus. The Selection Committee will naturally favor papers within this limitation, and which can be presented with reasonable completeness within the time limit.

Time Limit: The minimum length of a paper is 15 minutes; the maximum length is 25 minutes.

Form of Paper: Four copies of the paper to be presented, together with a description of the charts, models, or other visual aids that are to be used in the presentation, should be presented in typewritten form, following the normal techniques of term paper presentation. It should be presented in the form in which it will be presented, including length. (A long paper should not be submitted with the idea it will be

shortened for presentation.) Appropriate footnoting and bibliographical references are expected. A cover sheet should be prepared which will include the title of the paper, the student's name (which should not appear elsewhere in the paper), a designation of his/her classification in school (graduate or undergraduate), the student's permanent address, and a statement that the author is a member of Kappa Mu Epsilon, duly attested to by the Corresponding Secretary of the Student's Chapter.

Date Due: January 18, 1989

Address to Send Papers:

Dr. Harold L. Thomas
Mathematics Department
Pittsburg State University
Pittsburg, KS 66762

Selection: The Selection Committee will choose about fifteen papers for presentation at the convention. All other papers will be listed by title and student's name on the convention program, and will be available as alternates. Following the Selection Committee's decision, all students submitting papers will be notified by the National President-Elect of the status of their papers.

Criteria for Selection and Convention Judging:

A. The Paper

1. Orginality in the choice of topic

2. Appropriateness of the topic to the meeting and audience

3. Organization of the material

4. Depth and significance of the content

5. Understanding of the material

B. The Presentation

1. Style of presentation

2. Maintenance of interest

3. Use of audio-visual materials (if applicable)

4. Enthusiasm for the topic

5. Overall effect

6. Adherence of the time limit

Prizes: The author of each paper presented at the convention will be given a two-year extension of his/her subscription to The Pentagon. Authors of the four best papers presented by undergraduates, based on the judgment of the Awards Committee, composed of faculty and students, will be awarded cash prizes of $60, $40, $30, and $20 respectively. If enough papers are presented by graduate students, then one or more prizes will be awarded to this group.

Prize winning papers will be published in The Pentagon, after any necessary editing. All other submitted papers will be considered for publication at the discretion of the Editor.

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Full Time Positions —Research, apply and create advanced concepts from Galois theory and combinatorics to probability theory and astrodynamics. Focus on pure math, or branch out. Training available for continued career development. Must have Bachelor's Degree, Master's or Ph.D. with a 3.0 GPA or better to qualify.

Sabbaticals —Math sabbaticals run from 9 to 24 months. Mathematical achievement is a main criterion for selection. NSA will supplement mathematicians' university stipends to at least equal their monthly salary. Mathematicians are given the opportunity to interact with mathematicians both within and outside the agency. NSA offers a challenging environment. Application deadline is early August.

Summer Programs —Summer positions offer mathematicians the opportunity to do real math in an exciting environment including math workshops. Programs run for at least twelve weeks. Must be a junior or senior in college or in graduate school with a 3.0 GPA or better. Application deadline is mid-November.

Cooperative Education —Co-op programs available for sophomores through graduate students who want a "real-world" education. NSA's co-op program gives you an unbeatable advantage. Applicants must have a 3.0 GPA or better to qualify. Two six- month tours or three or four semester tours are available.

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