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http://kme.eku.edu/

Below is a partial list of items that are available on the site:

- How to start a KME chapter
- Information on KME conventions
- The cumulative subject index of The Pentagon

You can get a web page template from the Kentucky Alpha chapter. Its URL is

http://math.eku.edu/PJCostello/kme/

When you design a chapter homepage, please remember to make it clear that your page is for your chapter, and not for the national organization. Also,please include al link to the national homepage and submit your local chapter webpage's URL to the national webmaster. By doing so, other chapters can explore activities of your chapter and borrow some great ideas from you!

Call for Papers for the Thirty-Fifth Biennial Convention of Kappa Mu Epsilon

The Thirty-Fifth Biennial Convention
of
Kappa Mu Epsilon
will be hosted by the

Texas Mu chapter
at
Schreiner University
in
Kerrville, TX.

The convention will take place

April 14-16, 2005.

A significant feature of our national convention will be the presentaiton of papers by student members of Kappa Mu Epsilon. The mathematical topic selected by ech student should be of interest to the author and of such scope that it can be given adequate treatment in a timed oral prentation. Senior projects and seminar presentations have been a popular way for faculty to get students to investigate suitable topics.

Deadline for receiving papers:

February 1, 2005

Information about paper submission and presentaiton is available at

www.kme.eku.edu/announce.html

and in the Spring, 2004 issue of THE PENTAGON.

Chaotic Systems and Chua's Circuit

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Presented at the 2004 North Central Regional Convention and awarded "top three" status by the Awards Committee.

Abstract

A theoretical and numerical study of chaos in dynamical systems is considered. The Chua's circuit, consisting of a passive RLC_1C_2 block coupled with an active nonlinear resistor, is taken as model for such systems because of its simplicity and at the same time because it exhibits a rich variety of different dynamical behaviors such as bifurcations and chaos. We are interested in local and global analysis of the Chua's circuit, from the theoretical point of view, but we also present some numerical examples to confirm and illustrate the main ideas underlying chaotic dynamical systems. We remark the fact that this study can be performed with only some basic knowledge in differential equations and linear algebra at the undergraduate level.

1. Introduction

Chaos is a phenomenon that occurs widely in dynamical systems. There is, however, no general agreement within the scientific community as to what constitutes a chaotic dynamical system. We could describe it as a system that is sensitive to small changes in the initial data, and becomes unpredictable over time. This phenomenon was considered to be complex and was never given the proper importance because there was no simple analysis available. Chaotic phenomena are important in real-world applications, including secure communication, meteorology, chemical reactions, biology, electrical circuits, signal processing, and fractal theory.

Chua's Circuit is known as a rich repertoire of nonlinear dynamical phenomena and has become a universal paradigm for chaos. The first reason for choosing the Chua's circuit as the illustrative case of chaos is mainly because of its simplicity. Though simple, it exhibits a great variety of chaotic phenomena typically encountered in more complex systems; this has made it a very popular circuit. A second reason, which may be taken as a consequence of the first one, is that with a very simple case study, like Chua's circuit, it is really possible to gain a good understanding of the complexity and beauty of dynamical systems and chaos in general, with just an elementary background on ordinary differential equations and linear algebra, so that this work fits within the possibilities of undergraduate research, yet it considers topics and techniques usually considered only at graduate level.

Chua's circuit is an autonomous dynamical system because there is no external signal injected into the system. This terminology is used in general to denote those systems with a vector field that does not explicitly depend on time. Although most of the paper is devoted to highlight the theoretical aspects of chaos in dynamical systems, and to naturally connect undergraduate background with graduate-level research, we also take special care of illustrating the main ideas through numerical examples; to this end, we make extensive use of MATLAB and AUTO [3], not only for their graphical capabilities, but also for their suitability in the analysis and solution of differential equations and related topics such as bifurcation analysis. We believe that the merit of this work is the construction of a simple and short path from undergraduate background to a modest but challenging level of study in the area of (theoretical and numerical) dynamical systems and chaos.

2. Preliminaries

On our route to chaos, several definitions, theorems and other results on differential equations and dynamical systems will first need to be introduced. Before we go into the nonlinear dynamics, we will briefly explain how linear systems work, illustrating the main concepts by means of a RLC circuit. These ideas will be a crucial tool to study nonlinear dynamic systems. In the nonlinear systems, we study the local behavior, how the solutions behave around the equilibrium points and around periodical orbits, and the global behavior of the solutions. In the global study, one can encounter periodic orbits, heteroclinic and homoclinic solutions (trajectories connecting special sets [2]), bifurcations, and chaos. However, in this paper, we focus more on the study of chaos. We use the simplicity of Chua's circuit to explain very complex chaotic phenomena.

Definition and Notations:

We consider nonlinear systems of differential equations of the form

$$\begin{cases} \dot{X} = F(X(t),t); X \in R^n \\ F : R^n \to R^n \end{cases} \tag{1}$$

where

$$F(X(t),t) = (F_1(X(t),t), F_2(X(t),t), \ldots, F_n(X(t),t)$$

is called a *vector field*. In particular, if $F(X(t),t) = AX$, where A is a square matrix, then we say the system is linear. An *equilibrium point* is a vector x for which the vector field F is zero. A *periodic solution* of (1) of minimum period τ is a solution for which $F(X, t+\tau) = F(t)$, for all t in $\mathbb{R}$. A *periodic orbit* is the corresponding closed solution curve.

Existence and Uniqueness Theorem [1]:

Suppose that $F \in C(E)$, where E is an open subset of $\mathbb{R}^n$. Then $X(t)$ is a solution of the differential equation (1) on an interval I if $X(t)$ is differentiable on I and for all $t \in I$, $X(t) \in E$ and $X'(t) = F(X(t))$. Given $X_0 \in E$, $X(t)$ is a solution of the initial value problem

$$\begin{cases} \dot{X} = F(X) \\ X(t_0) = X_0 \end{cases}$$

on an interval I if $t_0 \in I$, $X(t_0) = X_0$, and $X(t)$ is a solution of the differential equation (1) on the interval I.

In this work, we assume that F is smooth enough so that the theorem above is valid.

3. Linear Systems

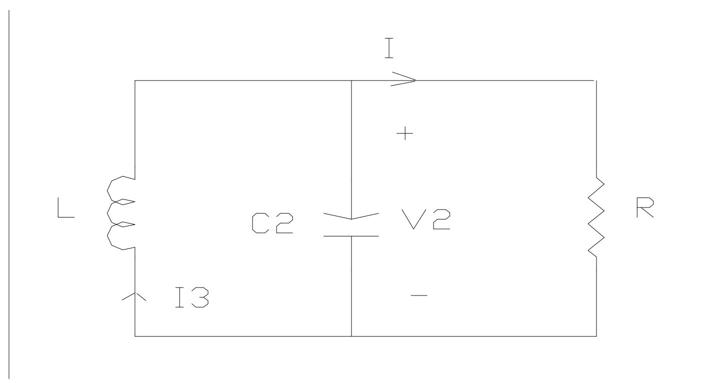
We first consider linear systems of differential equations of the form:

$$\begin{cases} \dot{X} = A(X(t), t) \\ X(0) = X_0 \end{cases}, X(t) \in \mathbb{R}^n , \qquad (2)$$

where X_0 is the initial solution, and $\dot{X}$ denotes the derivative of $X(t)$ with respect to time. For this system, the general solution is

$$X(t) = e^{At} X_0. \qquad (3)$$

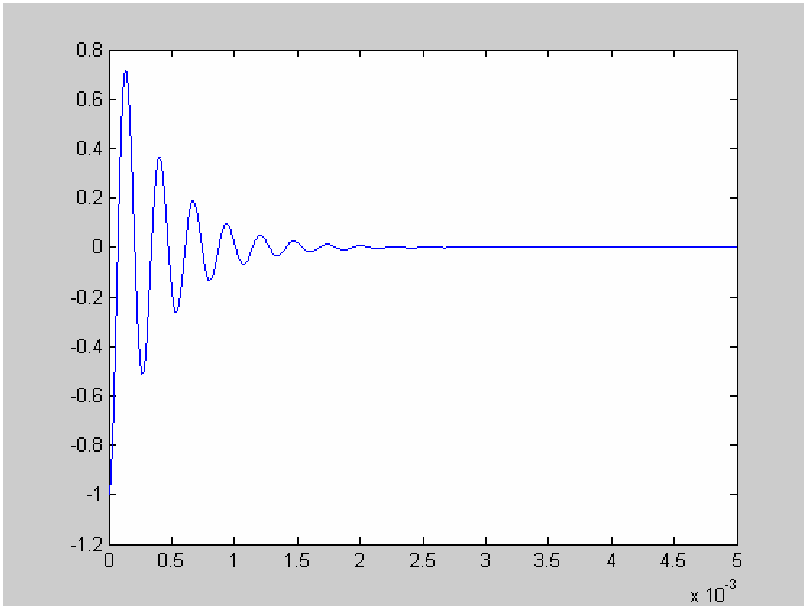
From this solution, it is clear that no chaos (for the moment, chaos meaning unpredictable solutions) can exist, because the solution is explicitly known for every time t. For example, consider the linear parallel RLC resonant circuit below:



Applying the KCL law and choosing V_2 and I_L as state variables, we obtain the system:

$$\begin{cases} \dfrac{dI_3}{dt} = -\dfrac{1}{L} V_2 \\ \dfrac{dV_2}{dt} = \dfrac{1}{C_2} I_3 - \dfrac{G}{C_2} V_2 \end{cases},$$

where G is conductance and $G = 1/R$. As remarked above, this system can be solved explicitly. With $L = 18$ mH, $C = 100$ nF, and $G = 500$ μs, we obtained the solutions to (3). In particular, using MATLAB, we show the solutions for this system in the figure below.



As we observe in the graph, no matter what we start from, the solution will go to zero.

The *stability* of system (2) is determined by the eigenvalues of the matrix A. In particular, if the real parts of all of the eigenvalues are strictly negative, the equilibrium point is asymptotically stable, and is called a sink because all nearby trajectories converge towards it. If any of the eigenvalues has a positive real part, the equilibrium point is unstable and is called a source. This should be clear from the fact that the solution can be explicitly written as in (3). Thus, eigenvalues with negative real part, will mean solutions decreasing exponentially to zero (the equilibrium solution). Similarly, eigenvalues with positive real part will mean solution increasing exponentially away from the origin.

Now let

$$w_j = u_j + iv_j$$

be a generalized eigenvector of the (real) matrix A corresponding to an eigenvalue

$$\lambda_j = a_j + ib_j,$$

and let

$$B = \{u_1, ..., u_k, u_{k+1}, v_{k+1}, ..., u_m, v_m\}$$

be a basis of $\mathbb{R}^n$ (with $n = 2m - k$). Then we define the *stable, center,* and *unstable subspaces* of (2) by

$$\begin{cases} E^s = \text{Span}\{u_j, v_j | a_j < 0\} \\ E^c = \text{Span}\{\{u_j, v_j | a_j = 0\} \\ E^u = \text{Span}\{\{u_n, v_j | a_j > 0\} \end{cases},$$

where E^s, E^c, and E^u are subspaces of $\mathbb{R}^n$ spanned by the real and imaginary parts of the generalized eigenvectors w_j corresponding to eigenvalues λ_j with negative, zero, and positive real parts respectively. These sets are *invariant*, in the sense that solutions starting in any of these sets will evolve with time but never leave that set. Even more, solutions approaching the equilibrium point will do it tangentially to E^s, and solutions going away from the equilibrium point will do it tangentially to E^u. For further details, see [4] and [7].

4. Nonlinear Systems

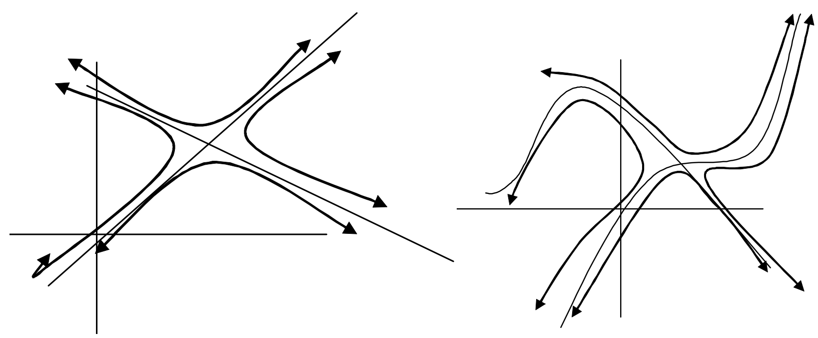
The main feature of nonlinear systems that differs from linear systems is that even when the function F in (1) is smooth and bounded for all $X \in \mathbb{R}$, the solution $X(t)$ may become unpredictable or unbounded at some finite time t. In general, it is not possible to explicitly solve the nonlinear system, in part because the systems are complex and the behavior of the solution may change dramatically as the initial conditions or some problem parameters change. Some numerical approximations of these solutions will be needed.

We divide the study of nonlinear systems into the local and global cases, and we use the results given above for the linear case.

Local behavior

A direct benefit of understanding the theory in the dynamics of linear systems is that the corresponding tools and results can be used to study a nonlinear system, at least locally, around some special sets, a technique known as *linearization*. In this work we consider linearization around equilibrium points and around periodic orbits.

Linearization around equilibrium points: In general, it is not possible to solve the nonlinear system (1); however, a great deal of qualitative information about the local behavior of the solution is established by the *Hartman-Grobman theorem***,** which states that, provided the Jacobian $DF(x_0)$ has no eigenvalues with zero real part (hyperbolic equilibrium), the nonlinear system (1) has the same qualitative structure as the linear system (2), with $A = DF(x_0)$, around that equilibrium point. Based on this very important result, we linearize the system (1) around each equilibrium point, and perform a local analysis of the solution. The figure below illustrates the behavior of both systems around an equilibrium point. See [4] and [7].



Linear system Nonlinear system

Consequently, the local stability of (1) is determined by the eigenvalues of the Jacobian. We consider the equilibrium points to be known (they can be computed by applying Newton's method to the nonlinear system $F(X) = 0$).

Linearization about periodic orbit: A similar local study as the one around a hyperbolic equilibrium can be performed by linearizing the system around a periodic orbit. To this end, we need to provide some definitions, in particular what we mean by stable or unstable subspaces of a periodic orbit.

A periodic orbit of (1) of period 1 can be computed as solution of the boundary value problem (see [2], [7])

$$\begin{cases} \dot{X} = F(X) \\ X(0) = X(1) \end{cases} . \tag{4}$$

The linearization of (1) around a periodic orbit will give us a linear system of the form (2), where $A(t)$ will be the Jacobian evaluated at the periodic orbit. A *fundamental matrix* for (2) is a nonsingular $n \times n$ matrix $\Phi(t)$ which satisfies the matrix differential equation

$$\begin{cases} \dot{\Phi} = A(t)\Phi, t \in \mathbb{R} \\ \Phi(0) = I \end{cases} .$$

If the periodic orbit has period τ, then we define the *monodromy matrix* as $\Phi(\tau)$. The eigenvalues of this matrix (known as *Floquet multipliers*) determine the stability properties of the periodic orbit, much in the same way the Jacobian determines the stability around equilibrium points. Furthermore, suppose that we have a basis of generalized eigenvectors of $\Phi(\tau)$ for $\mathbb{R}^n$ given by

$$\{u_1, ..., u_k, u_{k+1}, v_{k+1}, ..., u_m, v_m\}.$$

We then define the *stable, unstable, and center subspaces* of the periodic orbit τ at the point $0 \in \tau$ as

$$\begin{cases} E^s = \text{Span}\{u_j, v_j, |\mu| < 1\} \\ E^c = \text{Span}\{u_j, v_j, |\mu| = 1\} \\ E^u = \text{Span}\{u_n, v_j, |\mu| > 1\} \end{cases},$$

where μ are the eigenvalues of the monodromy matrix. If the monodromy matrix has exactly one eigenvalue μ, with $|\mu| = 1$, then the periodic orbit is called *hyperbolic*.

Remark: Hyperbolicity happens to be a property closely related to a type of stability (structural stability) and allows the development of theory and numerical tools necessary for the computation of special solutions (see [2]).

The following example, taken from [7] illustrates the ideas above.

$$\begin{cases} \dot{x} = x - y - x^3 - xy^2 \\ \dot{y} = x + y - x^2y - y^3 \\ \dot{z} = \lambda z \end{cases}.$$

This system has a periodic orbit $(\cos t, \sin t, 0)$, of period 2π, which, as remarked before, can be computed as solution of a boundary value problem. The Jacobian is

$$J_F(\mathbf{x}) = \begin{bmatrix} 1 - 3x^2 - y^2 & -1 - 2xy & 0 \\ 1 - 2xy & 1 - x^2 - 3y^2 & 0 \\ 0 & 0 & \lambda \end{bmatrix},$$

where $\mathbf{x} = (x, y, z)^T$. The linearization of the above system about the periodic orbit is then given by (2), where A is the Jacobian matrix above, evaluated at the periodic orbit, namely:

$$A(t) = \begin{bmatrix} -2\cos^2 t & -1 - \sin 2t & 0 \\ 1 - \sin 2t & -2\sin^2 t & 0 \\ 0 & 0 & \lambda \end{bmatrix}.$$

On the other hand, the corresponding linear system has the fundamental matrix

$$\Phi(t) = \begin{bmatrix} e^{-2t}\cos t & -\sin t & 0 \\ e^{-2t}\sin t & \cos t & 0 \\ 0 & 0 & e^{\lambda t} \end{bmatrix},$$

which satisfies $\Phi(0) = I$. We evaluate $\Phi(t)$ at 2π and this gives the monodromy matrix. We computed its eigenvalues with $\lambda = 1/2$ by using MATLAB. The eigenvalues are 0, 1, and 4.8105. Thus, we have a hyperbolic periodic orbit, with a one-dimensional stable subspace (one Floquet multiplier with magnitude less than one), and a one-dimensional unstable subspace (one Floquet multiplier with magnitude larger than one).

Global behavior

If we plan to understand the qualitative behavior of solutions of a general nonlinear system (1), the local study around equilibrium points and periodic orbits will be a very important step towards it, but it will not give us any information about the solution away from those invariant sets. The global study is a more complex matter and is still subject of current research. In the global study, one investigates phenomena such periodic orbits, heteroclinic and homoclinic trajectories, bifurcations, and chaos. We focus our study in chaos, but this concept is closely related to the other concepts and phenomena mentioned above.

We say the system (1) has a bifurcation if there is a clear change in the qualitatively behavior of the solution when a problem parameter varies. More specifically, in the study of bifurcations, one considers the parameter-dependent system

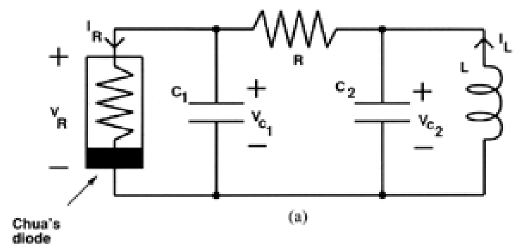
$$\dot{X} = F(X, \lambda), \tag{5}$$

where λ is the parameter. In the central example of this work (Chua's circuit), we will consider a system of this type, and perform some basic bifurcation analysis. There are many different types of bifurcations but in this paper, we will briefly cover the so-called *Hopf Bifurcation* phenomenon, mainly characterized by the appearance of periodic orbits for certain values of the parameter [4].

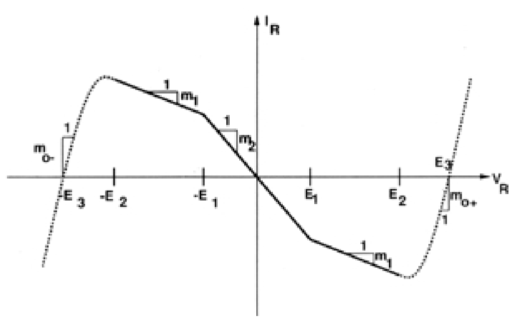
5. Chaos and the Chua's Circuit

The main goal of this work is to give a brief introduction to the ideas underlying the notion of chaos, by studying the system of differential equations (dynamical system) that models the Chua's circuit. We will compute several solutions to this system, for different values of the main problem parameter, and along the way, we will illustrate some concepts encountered in the theory of dynamical systems. It is worth noting that in the same way the RLC resonant circuit is the established paradigm in linear oscillatory behavior, the Chua's circuit is considered to be the paradigm for chaos.

As the figure below shows, the Chua's circuit consists of two capacitors C_1, C_2, one resistor R, one inductor L, and one non-linear resistor (the Chua's diode). Observe that the main difference between the Chua's circuit and the RLC circuit presented in section 3 is the introduction of the non-linear resistor. Several realizations of this non-linear resistor have been implemented, e.g. [6], [8].



Chua's Circuit



Driving-point characteristic of Chua's Diode

If we let $X_1 = V_1$, $X_2 = V_2$ and $X_3 = I_3$, the system defining the Chua's circuit is

$$h(x) = a_1 x + \frac{1}{2}(a_0 - a_1)\left(|x+1| - |x-1|\right)$$

$$\begin{cases} \dot{X}_1 = \alpha[X_2 - h(x_1)] \\ \dot{X}_2 = X_1 - X_2 + X_3 \\ \dot{X}_3 = -\beta X_2 \end{cases},$$

where we take the values $a_0 = \frac{2}{7}$, $a_1 = \frac{3}{14}$, $\beta = 14.3$, and α is a free parameter. The function $h(x)$ characterizes the nonlinearity of the circuit (the piece-wise linear function in the figure above). Observe that this function $h(x)$ is not smooth, and hence the solution may have some non-smooth derivatives. Thus, the smooth approximation

$$|x| \approx \frac{2}{\pi}\arctan(kx),$$

with $k = 10$ is used instead.

The Jacobian matrix is

$$J(x) = \begin{bmatrix} \alpha h'(x_1) & \alpha & 1 \\ 1 & -1 & 1 \\ 0 & -\beta & 0 \end{bmatrix},$$

where

$$h'(x_1) = a_1 + \frac{10}{\pi}(a_0 - a_1)\left[\frac{1}{1+100(x+1)^2} - \frac{1}{1+100(x-1)^2}\right].$$

In particular, at the equilibrium point $(0,0,0)$, we have

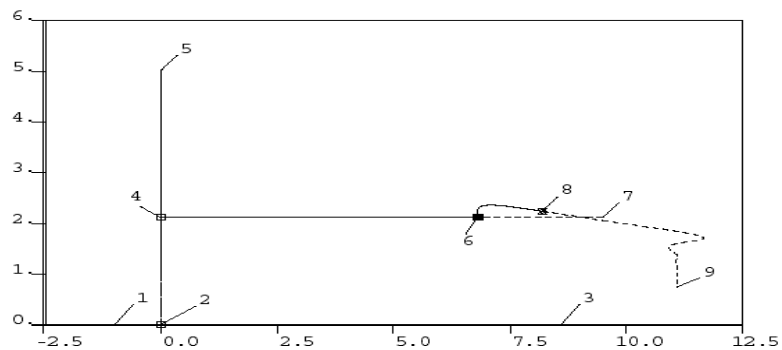
$$J_F\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} = \begin{bmatrix} 0 & \alpha & 0 \\ 1 & -1 & 1 \\ 0 & -\beta & 0 \end{bmatrix}.$$

We find the eigenvalues from

$$\lambda = \frac{-1 \pm \sqrt{1 + 4(\beta - \alpha)}}{2}.$$

Bifurcation diagram

We begin our analysis by showing the bifurcation diagram of Chua's system with starting value $\alpha = -1$, obtained by using AUTO 2000 [3].

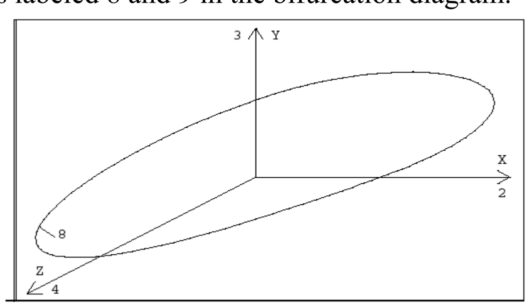


BIFURCATION DIAGRAM

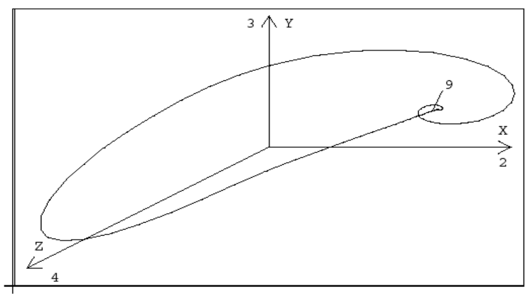
In this bifurcation diagram, we plot the magnitude or norm of the solution $||x||$ on the vertical axis, versus the parameter α on the horizontal axis. A solid line means stable and a dashed line means not stable. Running AUTO, several paths of solutions are computed and labeled (1 through 9). The parameter has moved from -1 to 11.07. At label 2, a branch point (a point where branches of equilibrium solutions are born) has been detected, for $\alpha = 0$. There is a second branch point at label 4. Following the second branch point, a Hopf bifurcation has been detected (label 6).

Periodic Orbits

Following this Hopf bifurcation, two periodic orbits appear, the first orbit with period 2.2835 (for $\alpha = 8.196013$) and the second one with period 19.3835 (for $\alpha = 11.07941$). The diagrams below show the two periodic orbits labeled 8 and 9 in the bifurcation diagram.

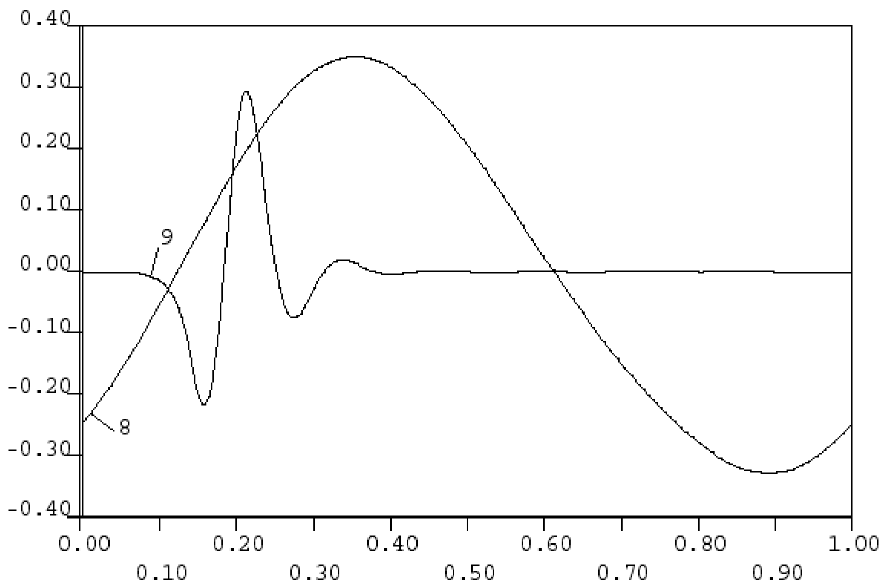


PERIODIC ORBIT 8



PERIODIC ORBIT 9

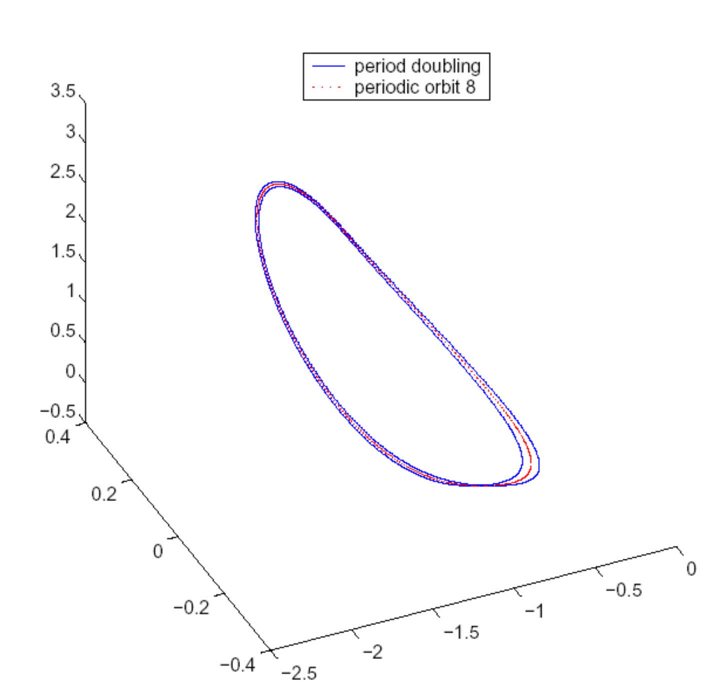
Next, in the figure below, we show the third components of both periodic orbits as functions of time (scaled to $[0, 1]$). Their periodic behavior is apparent.



SECOND COMPONENT

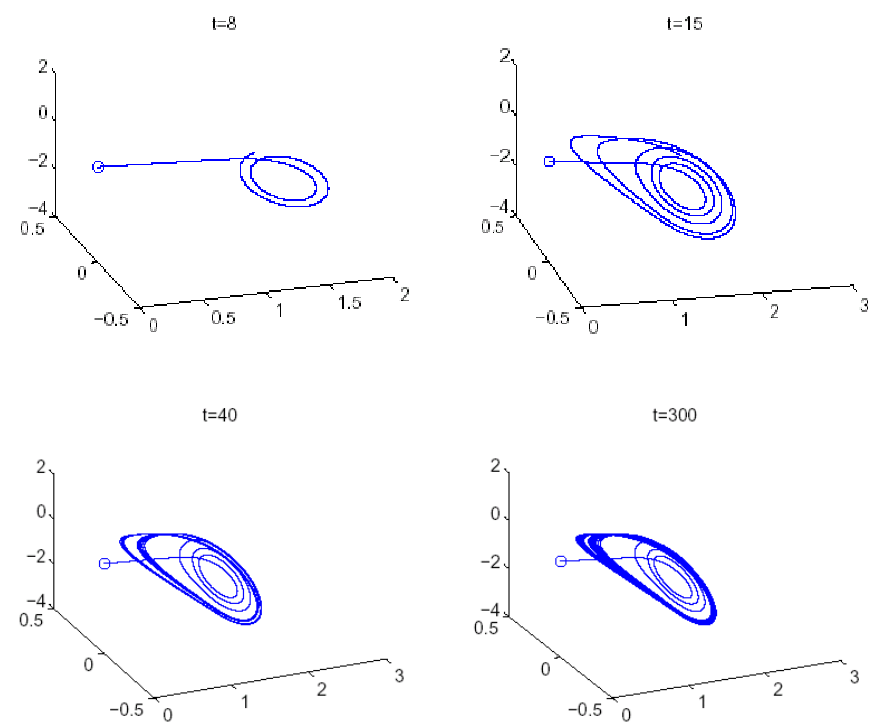
Sensitivity to initial data

So far, no clear indications of chaos have been detected in this system. To show that this dynamical system is sensitive to small changes in the data (one sign of the presence of chaos), we solve it again for $\alpha = 8.196$ (not $\alpha = 8.196013$) and as initial guess we take one point (modified to an error of about 10^{-4}) of the periodic orbit computed above, expecting to obtain the same periodic orbit with label 8. However, we obtain a different periodic orbit, which seems to "encircle" the first one, as shown in the figure below. Sensitivity is illustrated.

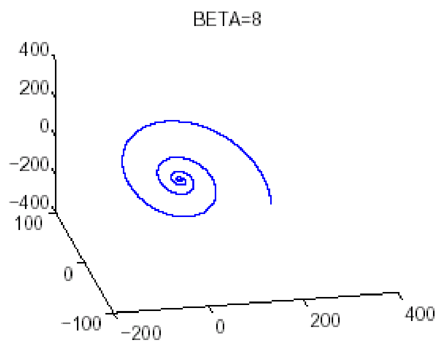


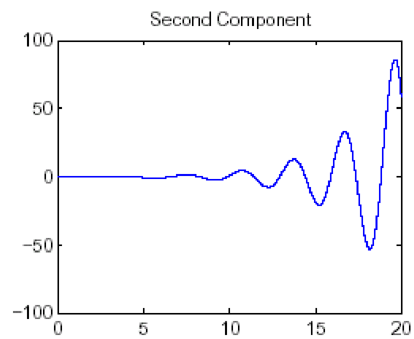
Strange attractors

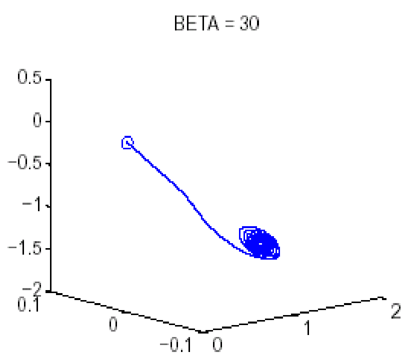
Next, we compute other solutions to Chua's circuit. The origin $(0, 0, 0)$ is an equilibrium point, and the Jacobian evaluated there has one zero eigenvalue and two eigenvalues with negative real part, so we expect solutions starting nearby at least to stay around the origin as time evolves. Thus, we start the solution at $(0, 0, 0.001)$, but the computed trajectories go away from the origin and seem to converge to a strange attracting set, where trajectories are interleaved and which intersect, and we have no precise prediction to where it goes next (although from a relatively far zoom out, the set seems to be very well defined). See figures below. The little circle denotes the initial point of the solution.

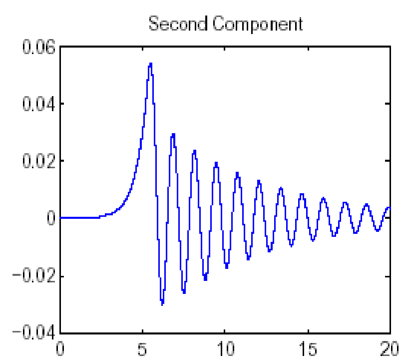


For further illustration, we show other solutions for different values of β (which was initially set to 14.3). In the first two plots, the solution stays close to zero for some time, but it then spirals away from it, very fast. In the last two plots, with $\beta = 30$, the solution start from zero, and then it spirals down away from it.

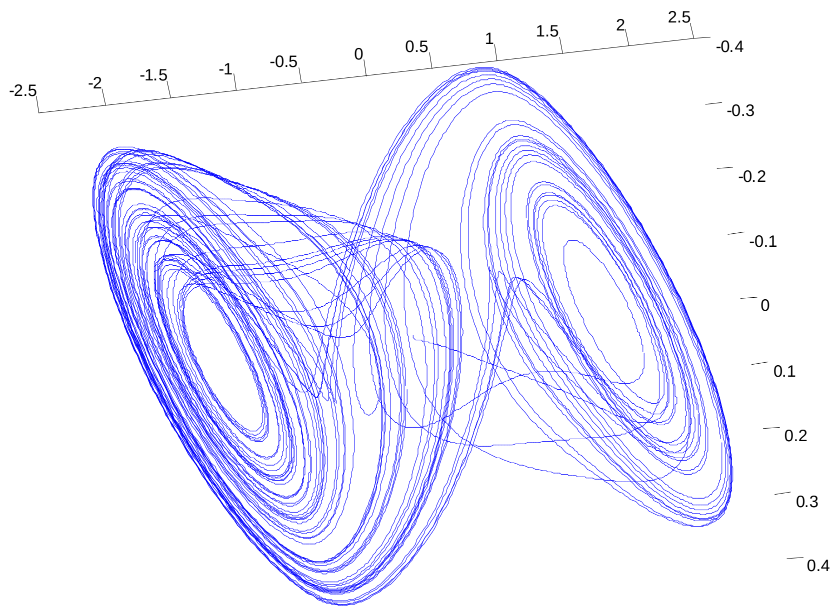








Finally, we compute another strange solution to Chua's circuit, which is known in the literature as *double-scroll attractor*. This type of strange attractors has often been mistaken for experimental noise, but they are now commonly found in digital filters and synchronization circuits. The strange solution below was obtained for $\lambda = 8.196$ and $\beta = 14.3$. Unpredictable behavior of solution is illustrated.



6. Conclusions

This paper introduces a phenomenon known as chaos, appearing very often not only in theoretical differential equations and dynamical systems, but also in several real-world applications. The main ideas behind the notions of dynamical system and chaos have been illustrated using a simple circuit known as the Chua's circuit. In particular, we characterize chaotic systems as those which are sensitive to small changes in the data, and whose behavior is unpredictable for large values of time. We guided the reader from the linear to the nonlinear dynamical systems. Throughout the paper, we have studied and illustrated concepts like equilibrium points, stability, local and global dynamics, periodic orbits, monodromy matrices, bifurcations, strange attractors, and chaos. We strongly believe, and it is suggested in this work, that the study of this circuit should be introduced at the undergraduate level. The reason is twofold: firstly, only basic notions of (undergraduate) linear algebra and differential equations are needed, and secondly, it should provide a deep motivation for students to pursue graduate studies in the mathematical sciences, physics and engineering.

Acknowledgements. I want to say special thanks to my advisor, Dr. Jorge L. Rebaza, who provided dozens of helpful comments and suggestions. Also, I want to say thanks to Dr. John Kubicek, who gave me an opportunity to present this paper.

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A Mathematical Model of Airport Efficiency

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Presented at the 2003 National Convention and awarded "top four" status by the Awards Committee

1. Introduction

Recently I challenged Professor Bob Robertson to work on an undergraduate research project with me that would combine my love for mathematics with my secondary education background, as well as researching, analyzing data, and computing statistics, which will provide experience towards my actuarial science degree. Dr. Robertson has enjoyed the process of mathematical modeling for years, so he was able to incorporate college level mathematics into a mathematical project that can be recreated in a way to teach middle school and high school students.

The mathematical modeling problem we decided to focus on comes from the Third Annual High School Mathematical Contest In Modeling (HiMCM), which presented this problem to contestants:

> The design of airline terminals varies greatly. The designs of airports (such as Boston-Logan, Munich International, Charlotte/Douglas International, Ronald Reagan Washington National, and Pittsburgh International) are quite dissimilar. Some involve circular arcs; others are rectangular; some are quite irregular. Which is optimal for operations? Develop a mathematical model for airport design and operation. Use your model to argue for optimality of your specified design. Explain how it would operate.

We decided to use this problem as a point of departure by creating a numeric equation to measure the efficiency of the airport. In mathematical modeling, it is important to understand that in order to solve the problem, the problem must be simplified and assumptions must be made. Therefore, we decided to focus on this main issue: Can we calculate the probability that passengers will miss their connecting flights based on a constant walking speed, when looking at select airports to determine the most efficient airport?

We were able to devise a technique that calculates the probability a randomly selected person might miss his or her connecting flight. We organized the data of the distances passengers had to walk between connecting gates. Using an average walking speed of the passengers, we are able to determine that if the passengers distance to travel, at the average speed, would take more time then their total walking time, then the passenger would miss his or her flight. Our technique allows us to compare different airports by concluding that airports with a smaller probability of passengers missing their connecting flights are more efficient.

2. Background

We will use several types of probability distribution. Two important types are the normal distribution and the uniform distribution. The normal distribution is known as the bell-shaped curve, or the Gaussian Distribution. Normal distributions can be specified according to the mean, μ, and the standard deviation, σ. The probability density function for a normal distribution is:

$$\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

A probability density function is a mathematical function whose graph creates a curve, which describes the distribution of probability for a continuous random variable. A probability density function has properties of

- The total area under the density curve is 1, and
- The density function never takes a negative value.

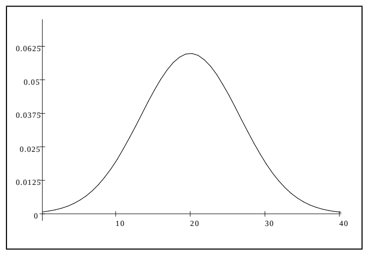
A probability density function is used by supposing that a and b are two possible values of a random variable, x, with density function, $p(x)$. Then, the probability that x lies between a and b is calculated by the following integral:

$$\int_a^b p(x)dx$$

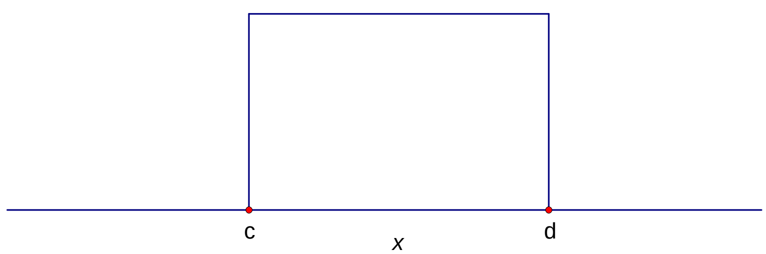
For example, if a random variable, x, has a normal distribution with mean, μ, and standard deviation, σ, then the probability that x falls between the values a and b can be found by computing:

$$\frac{1}{\sigma\sqrt{2\pi}}\int_a^b \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)dx$$

Below is the diagram of a normal distribution function with mean, $\mu =$ 20 minutes, and with standard deviation, $\sigma = 6.6667$ minutes:



Finally, a random variable, x, is uniformly distributed when no value of x that is between the two bounding values, c and d, is more likely to occur than any other value, and values of x that lie outside $[c, d]$ cannot occur. This density function looks like



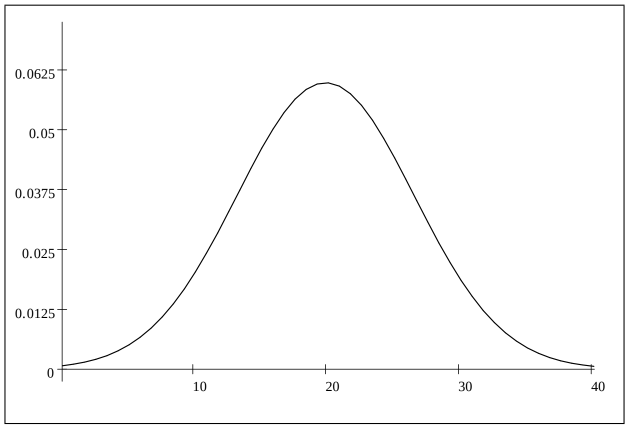
3. Constant Walking Speed Model

Assumptions

The model will be based on the following assumptions:

1. People will be walking between connecting flights at a constant walking speed, s_μ, or 3 miles per hour. According to sources; [1], [2], & [3], we determined that the average walking speed is 3 m.p.h.
2. The walkways will not be congested, and the subject(s) are able to move through the airport freely, at a constant speed, s_μ, or 3 m.p.h, without obstacles to slow them down.
3. Due to the variation of early and late arrivals, times between flights will be normally distributed with an average time between connecting

flights, t_μ, and standard deviation, t_σ. We will assume these numbers are; $t_\mu = 20$ minutes, and $t_\sigma = 6.66667$ minutes. The figure below represents this distribution:



4. The number of people who have connecting flights are evenly divided among the possible pair of gates, i and j.
5. We will assume that baggage will be transferred directly and efficiently by the aviation staff between connecting flights.
6. We will not distinguish between traveling from gate i to j, or j to i.

How the Model Works

For a given airport, calculate the distances between every possible pair of gates. We use $d(1,2)$, $d(1,3)$, $d(1,4)$,$\ldots$ to represent the distance between gates 1 & 2, 1 & 3, 1 & 4, respectively, and so on. To explain more explicitly, we will look at a specific passenger travelling between gates at the Munich Airport in Germany. If we concentrate on a passenger who arrives at Gate #8 and has to travel to Gate #18, they will have 10 gate gaps to pass, which are each 169.2 feet in length, according to the airport's site plans. Therefore, they will have $1,692$ feet to travel between flights. This is the example we will continue to use to illustrate our model.

In a hypothetical situation, a person will land at the airport and have a distance $d(i,j)$ between the gates. The person has time between connecting flights, $\check{T}$. For a possible pair of gates, we can calculate the walking time $w(i,j)$, by setting up the equation: $w(i,j) = \frac{d(i,j)}{s_\mu}$. Therefore, the person misses the connecting flight if

$$w(i,j) = \frac{d(i,j)}{s_\mu} > \check{T}.$$

In our example, the person who has to travel from Gate #8 to Gate #18 will be walking at an average of 3 m.p.h, and therefore, it will take the passenger 6.41 minutes to travel that distance. Therefore, if $\check{T} < 6.41$ minutes, the passenger will miss his or her flight.

Using the normal curve, we can calculate the probability of a connecting flight time that is less than $w(i,j) = \frac{d(i,j)}{w}$, which is the fraction of flights missed. We can calculate this by using the integral:

$$P(i,j) = \frac{1}{\sqrt{2\pi(6.667)}} \int_{-\infty}^{w(i,j)} \exp\left(-\frac{(x-20)^2}{2 \cdot 6.667}\right) dx$$

We can also figure the number of people who miss their flights by multiplying $N(i,j) = P(i,j) \cdot M(i,j)$, where $P(i,j)$ is the percentage of missed flights, $M(i,j)$ is the people traveling from gates i and j, and likewise, $N(i,j)$ is the number of people who do not make their flight. Therefore, the percent of people who will miss their flights is .0011 in our example of a randomly selected person travelling from Gate #8 to Gate #10.

Then, we are able to calculate the number of possible distances between gates, which we represent by g, where $\frac{1}{g}$ is the fraction of people in the airport with distance $d(i,j)$ to reach their connecting flight. In our Munich Airport example, there are 190 possible combinations between airport gates that any person can travel, represented by g. Ten of those possible distances will be equivalent to the distance a passenger walks from Gate #8 to Gate #18.

The next step is to compute the total number of people in the airport going from gates i to j by multiplying the number of people in the airport who have to make the connecting flight, A, by the fraction of people who have the distance, $d(i,j)$ to travel, $\frac{1}{g}$,which equals $M(i,j)$, which represents the percent of flights missed between gates i and j . Therefore, we now know that $N(i,j)$, the fraction of people who miss connecting flight between $d(i,j)$,equals $P(i,j)$, which is the percent of flights missed between gates i and j, by $(\frac{A}{g})$,which is the percent of flights missed by people travelling from gate i to gate j.

Subsequently, we can calculate the total number of people who miss their flight going from i to j by summing all distances $N(i,j)$. Then, we sum the percentages of people who will miss their connecting flights in

Munich Airport to get a total of .017571 people who will miss their flights.

Finally, we can calculate the fraction of people in the airport who will miss their connecting flight by summing all distances $\frac{N(i,j)}{A}$. For example if there were only 100 people taking a connecting flight, $\frac{.017571}{100} = 1.7571$ people who will miss their flight.

Symbol	Meaning	Values
t	Connecting flight time	varies
t_μ	Average connecting flight time	20 min
t_σ	Standard deviation of connecting flight time	6.66667 min
s_μ	Average walking speed	3 mph or 264 ft/min
w	Walking speed	
A	The people in the airport who have connecting flights	
$d(i,j)$	Distance between gates i and j	
$w(i,j)$	Walking time between gates i and j	
$N(i,j)$	Fraction of people who miss connecting flight between gates i and j	
$P(i,j)$	Percent of flights missed between gates i and j	
$M(i,j)$	People traveling from gates i and j	
g	# of possible distances between gates i and j	

Airport Comparisons and Conclusion

After we went through this process for Munich's International airport, we also looked at Kansai International Airport in Osaka, Japan and Dubai International Airport in Dubai, United Arab Emirates. The data for each of the airports are listed on the pages following the list of references. Here is what we have concluded:

- Munich's airport efficiency rating was .017571 for 20 gates, which had a airport gap of 169.2 feet.
- Kansai's airport efficiency rating was .00342 for 7 gates, which had a airport gap of 173.8 feet.
- Dubai's airport efficiency rating was .01053 for 27 gates, which had a airport gap of 100.9 feet.

Therefore, the Kansai has the best efficiency rating, because the probability that a passenger will miss his or her flight is low. However, Kansai only has 7 gates in the whole airport. The next airport would be Dubai due to its low efficiency rating. If you look at the reasons why it is lower, you can tell that the airport has a smaller distance for passengers to walk between flights. Dubai is also the most efficient because it has 27 gates, compared to only 7 gates at Kansai.

4. Conclusion

In this model, we used a constant walking speed of 3 mph and we varied the connecting flight times. Asecond model that varies the walking speeds as well as the connecting flight times could be constructed to expand the problem further. This would include the use of a bivariate function, which can be calculated as a double integral.

Acknowledments. I would like to thank my cooperating professor, Dr. Robert Robertson, of Drury University for helping me with this mathematical model. He has guided me through a research project that is realistic and understandable, thanks to his instruction. I would also like to thank Dr. Charles Allen acting as my corresponding Secretary for Kappa Mu Epsilon, the Missouri Kappa Chapter. This project would not have been possible without their help.

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Munich International Airport

Possible distances between gates	% of pairs with that distance	Walking time between gates	z-score	Probability of missing flight	Fraction of missed flights
169.2	19/190	0.64 minutes	-2.9	0.0019	0.00019
338.4	18/190	1.28 minutes	-2.81	0.0025	0.000237
507.6	17/190	1.92 minutes	-2.71	0.0034	0.000304
678.8	16/190	2.57 minutes	-2.61	0.0045	0.00038
846	15/190	3.20 minutes	-2.52	0.0059	0.00047
1015.2	14/190	3.85 minutes	-2.42	0.0078	0.00057
1184.4	13/190	4.49 minutes	-2.33	0.0099	0.00068
1353.6	12/190	5.13 minutes	-2.23	0.0129	0.00081
1522.8	11/190	5.77 minutes	-2.13	0.0166	0.00096
1692	10/190	6.41 minutes	-2.04	0.0207	0.0011
1861.2	9/190	7.05 minutes	-1.94	0.0262	0.00124
2030.4	8/190	7.70 minutes	-1.84	0.0329	0.0014
2199.6	7/190	8.33 minutes	-1.75	0.0401	0.00148
2368.8	6/190	8.97 minutes	-1.65	0.0495	0.00156
2538	5/190	9.61 minutes	-1.56	0.0594	0.00156
2707.2	4/190	10.25 minutes	-1.46	0.0721	0.00152
2876.4	3/190	10.90 minutes	-1.36	0.0869	0.00137
3045.6	2/190	11.53 minutes	-1.27	0.102	0.0011
3214.8	1/190	12.18 minutes	-1.17	0.121	0.00064
Totals	190/190				0.017571

Kansai International Airport

Possible distances between gates	% of pairs with that distance	Walking time between gates	z-score	Probability of missing flight	Fraction of flights missed
173.8	2/7	0.66 minutes	-2.9	0.0019	0.00054
347.6	5/21	1.32 minutes	-2.8	0.0026	0.00062
521.4	4/21	1.98 minutes	-2.7	0.0035	0.00067
695.2	1/7	2.63 minutes	-2.61	0.0045	0.00064
869	2/21	3.29 minutes	-2.51	0.006	0.00057
1042.8	1/21	3.95 minutes	-2.41	0.008	0.00038
Totals	21/21				0.00342

Dubai International Airport

Possible distances between gates	% of pairs with that distance	Walking time between gates	z-score	Probability of missing flight	Fraction of missed flights
100.9	26/351	0.38 minutes	-2.94	0.0016	0.00012
201.8	25/351	0.76 minutes	-2.88	0.002	0.00014
302.7	24/351	1.15 minutes	-2.82	0.0024	0.00016
403.6	23/351	1.53 minutes	-2.77	0.0028	0.00016
504.5	22/351	1.91 minutes	-2.71	0.0034	0.00021
605.4	21/351	2.29 minutes	-2.66	0.0039	0.00023
706.3	20/351	2.68 minutes	-2.6	0.0047	0.00027
807.2	19/351	3.06 minutes	-2.54	0.0055	0.00030
908.1	18/351	3.44 minutes	-2.48	0.0066	0.00034
1009	17/351	3.82 minutes	-2.43	0.0075	0.00036
1109.9	16/351	4.20 minutes	-2.37	0.0089	0.00041
1210.8	15/351	4.59 minutes	-2.31	0.0104	0.00044
1311.7	14/351	4.97 minutes	-2.25	0.0122	0.00049
1412.6	13/351	5.35 minutes	-2.2	0.0139	0.00051
1513.5	12/351	5.73 minutes	-2.14	0.0162	0.00055
1614.4	11/351	6.12 minutes	-2.08	0.0188	0.00059
1715.3	10/351	6.50 minutes	-2.02	0.0217	0.00062
1816.2	9/351	6.89 minutes	-1.97	0.0244	0.00063
1917.1	8/351	7.26 minutes	–1.91	0.0281	0.00064

Dubai International Airport (continued)

Possible distances between gates	% of pairs with that distance	Walking time between gates	*z*-score	Probability of missing flight	Fraction of missed flights
2018	7/351	7.64 minutes	-1.85	0.0322	0.00064
2118.9	6/351	8.03 minutes	-1.8	0.0359	0.00061
2219.8	5/351	8.41 minutes	-1.74	0.0409	0.00058
2320.7	4/351	8.79 minutes	-1.68	0.0465	0.00053
2421.6	3/351	9.17 minutes	-1.62	0.0562	0.00048
2522.5	2/351	9.55 minutes	-1.57	0.0582	0.00033
2623.4	1/351	9.94 minutes	-1.51	0.0655	0.00019
Totals	351/351				0.01053

The Use of Numerical Analysis in Weather Forecasting

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Presented at the 2004 North Central Regional Convention

Abstract

Weather forecasting has become more accurate with time, yet there still remains uncertainties in forecasting. Severe weather tends to be one of the most inaccurately forecasted events. Inaccuracies in prediction of severe weather can turn deadly, as one incident in 2003 in Kansas showed. Evidence points to the use of numerical methods of weather forecasting to solve these problems. Numerical weather prediction is not the sole answer to this forecasting problem. An increase in the understanding of physical processes that the atmosphere undergoes during periods of severe weather activity must be obtained. A project using numerical analysis of atmospheric characteristics was performed during December of 2003. The numerical analysis was performed in an unusual way. This numerical analysis ignored the units of measurement for each individual atmospheric characteristic and focused on correlations between changes in atmospheric characteristics with respect to time. Unfortunately, the method failed to achieve adequate predictions and needs improvement before it can be a useful model.

1. Introduction

Weather is one of the most important facets of everyday life. Ordinary conversations between complete strangers or best friends often start by discussing the current "state" of the atmosphere. The effects of weather are obvious. For example, farmers plan their daily activities according to the short-term and long-term weather forecasts. Weather can be a limiting factor for several agricultural activities. Drought can reduce crop yield, hail can decimate a crop, heavy precipitation can delay planting, and extremely cold weather can pose major problems for livestock. Furthermore, a deficit of agricultural goods resulting from adverse weather could ultimately translate into economic uncertainties that affect the greater population. In one way or another, weather affects everyone.

The most fundamental problems associated with weather are due to our inability to accurately predict future atmospheric conditions at appropriate spatial and temporal scales. It is true that current forecasts are generated in a more efficient and accurate manner than 30 years ago, but improvements still need to be made. It is generally accepted that "forecasts made for between 12 to 24 hours are usually quite accurate. Those made for between 1 and 3 days are fairly good. Beyond about 5 days, however, forecast accuracy falls off rapidly" ([**?**], p. 231). USA Today reported that inaccuracies with forecasts for the next 12 hours are primarily associated with "local" severe storms that produce "small-scale events, such as tornadoes or flash floods" ([**?**], p. 182). This means that general area forecasts are correct, but significant local events are much more difficult to predict. Williams ([**?**]) also noted that forecasts from 12 to 48 hours are accurate for prediction of events such as the development of "large extra-tropical storm[s]", but not accurate in the prediction of the exact time and location for specific weather phenomena generated by these larger storm systems. Additionally, 3 to 5 day forecasts are more efficient at predicting temperature than precipitation, and 6 to 10 day forecasts are reliable in predicting "average temperatures and precipitation for the entire period," but rather erratic in predicting "day-to-day weather" (p. 182).

One obvious area for improvement in weather forecasting relates to the prediction of individual storm cells. Because severe storms can generate hazardous conditions (i.e., high winds, large hail, heavy rain, tornadoes), it would be optimal if we could accurately predict the duration, intensity, and spatial coverage of these storms hours in advance of their occurrence. Unfortunately, individual storms have different life spans and may produce severe weather over a limited area for only a limited amount of time. Different types of severe storms have different durations. For example, tornadoes may last only a few minutes while tropical cyclones may last for weeks ([**?**]). We can broadly categorize the life cycles of certain types of storms, but within each category of storm uncertainties still remain. For example, individual storm duration and changes in storm intensity are not easily or accurately predicted. Along with the issues of duration and intensity, predicting the actual location where storms reach greatest intensity is also problematic. Currently, forecasters are able to generalize areas of greatest risk for severe weather as the basis for severe weather watches and warnings, but within these watches and warnings, spatial coverage is not precise enough to predict specific storm tracks.

Though it may seem impractical today, my goal is to develop weather prediction "tools" that produce better predictions of duration, intensity, and spatial coverage of hazardous weather. Recently in Kansas, there was a disastrous incident resulting from insufficient warning of these three weather factors. On August 30, 2003, Jacob Creek near Emporia, KS experienced a flash flood that caused the creek to overflow and unexpectedly inundate a section of the Kansas turnpike. This event produced tragic results by claiming the lives of six people. The flood was reported to have the intensity of a 200-year flood, that is, the intensity of a flood experienced once every 200 years ([**?**]). When asked about the flood, U.S. Geological Survey geologists Charlie Perry said, "it just happened in the wrong spot at the wrong time" (p. 1). There is little doubt that more timely and precise warnings of such weather events are needed to save lives and avert similar disasters in the future.

2. Numerical Methods of Weather Forecasting

My principal area of interest in weather forecasting involves the use of quantitative methods to forecast severe weather associated with thunderstorms. As mentioned before, weather events such as tornadoes and flash floods associated with thunderstorms are difficult to predict. Charlevoix, et al. ([**?**]) stated that, "forecasting the precise location where a tornado will occur is impossible with current technology" (p. 361). While I am sure this is true, I am also quite intrigued by the challenge of developing the technology necessary to accomplish this type of prediction. If meteorologists were able to forecast the precise location of a tornado several hours in advance, it would surely reduce deaths caused by weather phenomena. I believe the "key" to unraveling problems associated with weather forecasting, such as tornado location, can be found using numerical methods of weather analysis and forecasting. Charlevoix, et al. stated that, "Identifying regions where tornadic storms are likely to form is done routinely using numerical forecast methods" (p. 361). Further, they note that numerical methods of weather forecasting are based on mathematical equations that represent the "behavior" of "physical and dynamical processes" characteristic of the atmosphere. Models are by nature simplifications of the natural world, therefore I do not believe that numerical modeling alone will solve our forecasting problems. Djuric ([**?**]) wrote that, "No model is perfect and no list of models can be exhaustive or final. As more evidence is collected, old models are revised and new models are introduced." It is clear that in order to achieve greater modeling capability, we must continue to research the mechanics of how storms form and intensify in order to determine the factors that must be present for them to produce hazardous weather. I believe an improved comprehension of such principles would lead to better model predictions. Concurrently, we must continue to refine our numerical methods to take full advantage of expanding computer technology in order to increase the resolution at which we can predict weather phenomena. I believe the combination of enhanced understanding of meteorological principles, better models, refined numerical analysis methods, and greater computer capabilities could produce substantially more accurate forecasts.

I have taken a primordial step in learning the basics of quantitative weather forecasting. During the fall of 2003, I was granted permission to undertake an independent study in weather forecasting. For this project, I researched past and present models of weather forecasting. From this, I designed my own simple method of numerical forecasting. I formulated my forecasting methods from analyzing weather data for Decembers in Emporia, Kansas from 1996 thru 2001. From this analysis, I looked for patterns that could aide in forecasting the atmospheric pressure, temperature, dew point, wind speed and precipitation. I decided to focus on forecasting these characteristics for 6 p.m. Here are the formulas I developed from this data (note that prev. stands for previous):

3. Formulas

Pressure

$$P = 3(6\text{ a.m. } P) - 3(12\text{ a.m. } P) + (\text{prev. 6 p.m. } P)$$

Temperature

$$T = (\text{prev. 6 p.m. } P) - (6\text{ p.m. } P) + (\text{prev. 6 p.m. } T)$$

Dew Point

- If $(6 \text{ a.m. } T - 6 \text{ p.m. } T) < 0$, then
$$D = (6 \text{ a.m. } T) - (6 \text{ p.m. } T) + (6 \text{ a.m. } D)$$
- If $(6 \text{ a.m. } T - 6 \text{ p.m. } T) \geq 15$, then
$$D = (6 \text{ a.m. } T - 6 \text{ p.m. } T)/2 + (6 \text{ a.m. } D)$$
- If $0 \leq (6 \text{ a.m. } T - 6 \text{ p.m. } T) < 15$, then
$$D = (6 \text{ p.m. } T) + (6 \text{ a.m. } P) - (\text{prev. } 6 \text{ p.m. } D)$$

Wind Speed

$$WS = (6 \text{ a.m. } WS) + (12 \text{ a.m. } P) - (\text{prev. } 6 \text{ p.m. } P)$$

Precipitation

- If
$$\begin{cases} (6 \text{ p.m. } T - 6 \text{ p.m. } D) \leq 2 \\ 1.5 \leq \left| \dfrac{6 \text{ a.m. WS} - 12 \text{ a.m. WS}}{6 \text{ a.m. P} - 12 \text{ a.m. P}} \right| \leq 2.6 \\ \left| \dfrac{6 \text{ p.m. D} - \text{prev. } 6 \text{ p.m. D}}{6 \text{ p.m. T} - \text{prev. } 6 \text{ p.m. T}} \right| \leq 5 \\ (6 \text{ p.m. } T) > 32 \end{cases},$$
then there will be rain at 6 p.m.
- If
$$\begin{cases} (6 \text{ p.m. } T - 6 \text{ p.m. } D) \leq 2 \\ 1.5 \leq \left| \dfrac{6 \text{ a.m. WS} - 12 \text{ a.m. WS}}{6 \text{ a.m. P} - 12 \text{ a.m. P}} \right| \leq 2.6 \\ \left| \dfrac{6 \text{ p.m. D} - \text{prev. } 6 \text{ p.m. D}}{6 \text{ p.m. T} - \text{prev. } 6 \text{ p.m. T}} \right| \leq 5 \\ (6 \text{ p.m. } T) \leq 32 \end{cases},$$
then there will be snow at 6 p.m.
- If
$$\begin{cases} (6 \text{ p.m. } T - 6 \text{ p.m. } D) \geq 2 \\ \left| \frac{6 \text{ a.m. WS} - 12 \text{ a.m. WS}}{6 \text{ a.m. P} - 12 \text{ a.m. P}} \right| \leq 1.5 \text{ or } \left| \frac{6 \text{ a.m. WS} - 12 \text{ a.m. WS}}{6 \text{ a.m. P} - 12 \text{ a.m. P}} \right| \geq 2.6 \\ \left| \dfrac{6 \text{ p.m. D} - \text{prev. } 6 \text{ p.m. D}}{6 \text{ p.m. T} - \text{prev. } 6 \text{ p.m. T}} \right| \geq 5 \end{cases},$$
then there will be no precipitation at 6 p.m.

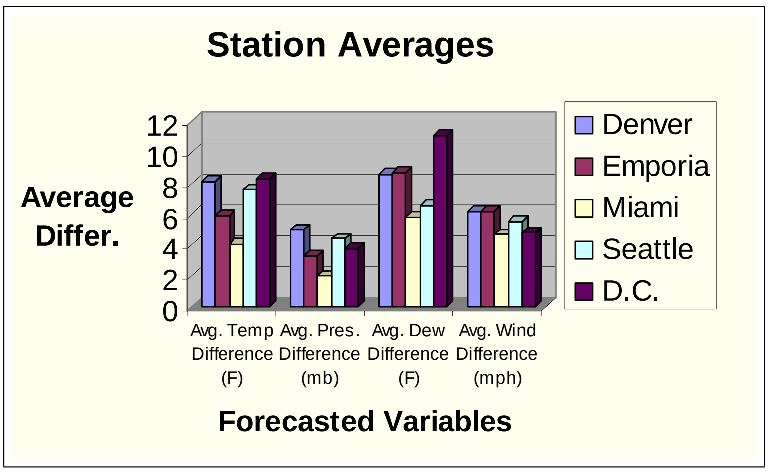
It must be noted that atmospheric pressure is being measured in millibars, temperature and dew point is being measured in degrees Fahrenheit, and wind speed is being measured in miles per hour. One disturbing fact, especially for physisists, was that I ignored units of measure when I made these formulas. For instance, my formula for temperature added pressure with temperature. Adding millibars and degrees Fahrenheit does not make since in the physical world. By ignoring units of measure, I was hoping to encounter some statistical correlation to help predict these atmospheric characteristics. Using these formulas, I created a simple forecasting model using the computer language C++ ([**?**]). I then proceeded to forecast the month of December 2003 for Denver, CO, Emporia, KS, Miami, FL, Seattle, WA, and Washington D.C. The results of my forecasting experience were the following:

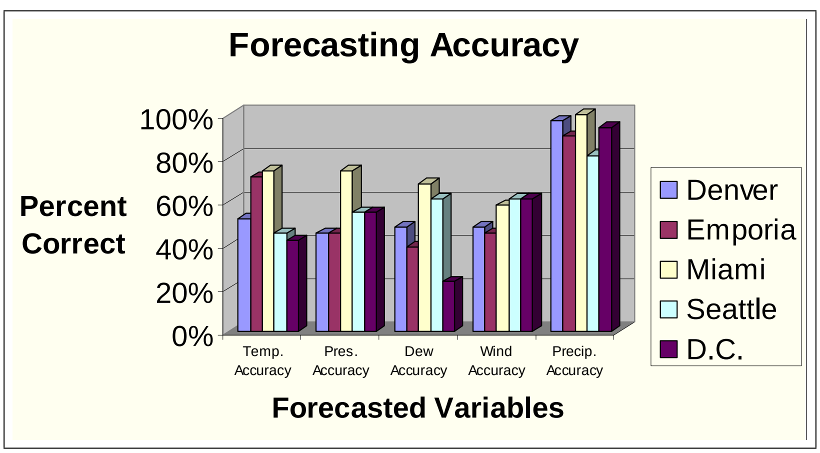
4. Results

ACCURACY OF THE FORECASTS

	Denver	Emporia	Miami	Seattle	D.C.
Temp. Accuracy	52%	71%	74%	45%	42%
Pres. Accuracy	45%	45%	74%	55%	55%
Dew. Accuracy	48%	39%	68%	61%	23%
Wind Accuracy	48%	45%	58%	61%	61%
Precip Accuracy	97%	90%	100%	81%	94%
Avg. Temp Diff.	8.1° F	5.9° F	4.1° F	7.6° F	8.3° F
Avg. Pres. Diff.	5.0 mb	3.3 mb	2.0 mb	4.4 mb	3.8 mb
Avg. Dew. Diff.	8.6° F	8.7° F	5.8° F	6.6° F	11.1° F
Avg. Wind Diff.	6.2 mph	6.2 mph	4.7 mph	5.5 mph	4.8 mph

Temperature was considered accurate if the predicted temperature was within plus or minus 5 degrees Fahrenheit of the actual temperature. Atmospheric pressure was considered accurate if the predicted atmospheric pressure was within plus or minus 3 millibars of the actual atmospheric. Dew point was considered accurate if the predicted dew point was within plus or minus 5 degrees Fahrenheit of the actual dew point. The wind speed was considered accurate if the predicted wind speed was within plus or minus 5 miles per hour. The precipitation was considered accurate if the predicted type of precipitation (if any) was the same as the actual type of precipitation (if any). Here are two bar graphs that represent this table:





5. Conclusions

Obviously improvements in this method are needed. The formulas were not manipulated to exclude false predictions, such as negative wind speeds and dew points greater than temperatures. These are just two conditions that could not happen on Earth and thus would need to be further developed. The question remains, whether improvements would be of value. Continued focus on areas of improvement would lead to better methods of forecasting in such troublesome areas, but no matter how much improvement is accomplished, the best that can be produced is an approximation. It is true that all current methods of forecasting approximate to some point, yet this may be what produces inaccuracies in current forecasts.

Acknowledgements. I would like to thank Dr. Richard Sleezer for his involvement in this project. Without his guidance and insight, I would not have been able to undertake this project and may have not developed my methods.

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[1] D. Ahrens, *Essentials of Meteorology: An Invitation to the Atmosphere*, 2nd ed., Wadsworth Publishing Company, Belmont, California, 1998.

[2] Associated Press, I-35 Flood Caused by Deluge, *The Emporia Gazette*, October 10, 2003.

[3] D. Charlevoix, R. Rauber, and J. Walsh, *Severe and Hazardous Weather*, Kendall-Hunt Publishing Company, Dubuque, Iowa, 2002.

[4] H. Deitel and P. Deitel, *C++: How to Program*, 4th ed., Prentice Hall, Upper Saddle River, New Jersey, 2003.

[5] D. Djuric, *Weather Analysis*, Prentice Hall, Englewood Cliffs, New Jersey, 1994.

[6] J. Williams, *The Weather Book*, Random House Inc., New York, 1997.

In Memoriam:
James Lester Smith

James Lester Smith, longtime friend and member of KME, was initiated into the Pennsylvania Alpha Chapter of Kappa Mu Epsilon in 1957 as a faculty member at Westminster College in New Wilmington, Pennsylvania. Moving later to Muskingum College in New Concord, Ohio, he was instrumental in the installation of the Ohio Zeta Chapter, of which he became the first Corresponding Secretary, serving in that capacity until his retirement in 1993. He served as Regional Director of Region 2 from 1975 to 1979, National President-Elect from 1981 to 1985, and National President from 1985 to 1989. At the 1995 KME National Convention in Durango, Colorado, Dr. Smith received the George R. Mach Distinguished Service Award. According to the citation for the award, Dr. Smith was "a source of inspiration and guidance to an entire generation of Muskingum students. In the classroom he was an enthusiastic teacher who cared deeply for his students." After 35 years at Muskingum, he taught part-time at Horry-Georgetown Technical College.

Born in Lackawanna, N.Y., Jim Smith lived a very active life. In addition to his professional life, which included a 50-year membership in the Mathematical Association of America, he was a member of Kingston Presbyterian Church and was a US Marine Corp. Veteran. He was a lifelong member of the Lions Club International. An avid traveler, Jim Smith did mission work in Egypt, New Mexico and Africa. He celebrated his 50 year wedding anniversary in May of this year.

Jim died of a heart attack October 25, 2004 at the age of 75, shortly after moving to Conway, South Carolina. His loss will be deeply felt.

The Problem Corner

Edited by Catherine Kong and 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 July 1, 2005. Solutions received after the publication deadline will be considered also until the time when copy is prepared for publication. The solutions will be published in the Fall 2005 issue of *The Pentagon*, with credit being given to the student solutions. Affirmation of student status and school should be included with solutions. Solutions to problems in this issue should be addressed to Kenneth M. Wilke, Department of Mathematics, 275 Morgan Hall, Washburn University, Topeka, Kansas 66621 (e-mail: ken.wilke@washburn.edu). All new problem proposals and all solutions for problems appearing in columns after this one should be addressed to Catherine Kong, Department of Natural and Mathematical Sciences, California Baptist University, 8432 Magnolia Ave., Riverside, CA 92504-3297 (e-mail: ckong@calbaptist.edu).

PROBLEMS 580-584

Problem 572. *Proposed by José Luis Díaz-Barrero, Universidad Politécnica de Catalunya, Barcelona, Spain.* (Recorrected). [The Editor apologizes for the typographical error in the last issue.]

Let z_1, z_2, and z_3 be nonzero complex numbers such that

$$z_1^3 + z_2^3 + z_3^3 = 0.$$

Show that

$$\frac{z_1^9 + z_2^9 + z_3^9}{z_1^3 z_2^3 z_3^3}$$

is an integer, and determine its value.

Problem 580. *Proposed by Russ Euler and Jawad Sadek, jointly, Northwest Missouri State University, Maryville, Missouri.*

Let x, y, z be nonnegative real numbers. Show that if

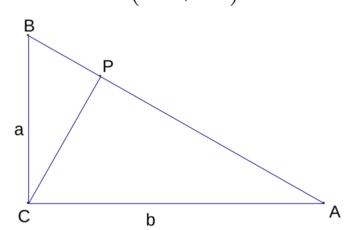
$$x^2 + y^4 + z^6 \leq 3,$$

then

$$x + 2y + 3z \leq 6.$$

Problem 581. *Proposed by Thomas Chu, Austin, Texas.*

Let triangle ABC be a right triangle with legs a and b and the right angle at C. Let O denote the circumcenter of triangle ABC. Let P be a point located on AB so that when CP is drawn, $CP \perp AB$. Show that the ratio of OP to AB is given by $\dfrac{|a^2 - b^2|}{2(a^2 + b^2)}$.



Problem 582. *Proposed by Pat Costello, Eastern Kentucky University, Richmond, Kentucky.*

Suppose that one fills in the ten blanks in the number

9_ _8_7_6_5_4_3_2_1_0

with all of the ten digits 0,1,2,...,9. What is the probability that the resulting 18-digit number is divisible by 528?

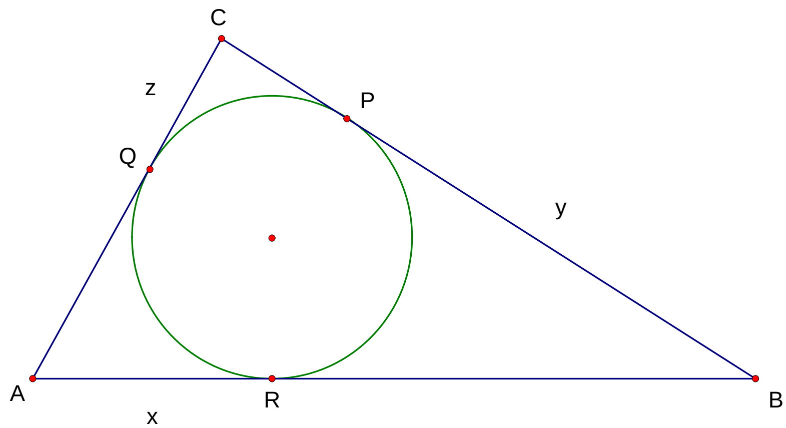
Problem 583. *Proposed by James R. Bush, Waynesburg College, Waynesburg, Pennsylvania.*

For an integer $n \geq 2$, consider the remainder term $A_n x + B_n$ which occurs when x^n is divided by the trinomial $x^2 - x - 1$. Find

$$\lim_{n \to \infty} \frac{A_n}{B_n}.$$

Problem 584. *Proposed by Thomas Chu, Austin, Texas.*

In triangle ABC, the incircle is tangent to AB, BC, and CA at P, Q, and R, respectively. Let $x = AR$, $y = BP$, and $z = CQ$. Let r be the radius of the inscribed circle. Prove that $\dfrac{x+y+z}{xyz} = \dfrac{1}{r^2}$.



Please help your editor by submitting problem proposals.

SOLUTIONS 570 – 574

Problem 570. *Proposed by Ovidiu Furdui, Western Michigan University, Kalamazoo, Michigan.*

Let ABC be a triangle and H its orthocenter. Prove that

$$(AH + BH + CH)\sqrt{3} = AB + BC + CA$$

if and only if at least one of the angles of triangle ABC is 60°.

Since no solutions have been received, this problem will remain open for another issue.

Problem 571. *Proposed by James R. Bush, Waynesburg College, Waynesburg, Pennsylvania.*

Find all values of a such that $x^2 - x + a$ divides

$$x^{15} + 27x^3 + 688x^2 - 1352x - 1092.$$

Solution *by José Luis Díaz-Barrero, Universidad Politécnica de Catalunya, Barcelona, Spain.*

Let

$$A(x) = x^{15} + 27x^3 + 688x^2 - 1352x - 1092$$

and

$$B(x) = x^2 - x + a.$$

Applying Euclid's Algorithm, we have

$$A(x) = B(x)Q(x) + R(x),$$

where

$$R(x) = f(a)x + g(a),$$

where

$$f(a) = -a^7 + 28a^6 - 126a^5 + 210a^4 - 165a^3 + 66a^2 - 40a - 636$$

and

$$g(a) = -7a^7 + 56a^6 - 126a^5 + 120a^4 - 55a^3 + 12a^2 - 716a - 1092.$$

The values of a for which $B(x)$ divides $A(x)$ are those for which $R(x) = 0$, that is, the values of a for which $f(a) = 0$ and $g(a) = 0$ are both true. Since the LHS of both of these equations are polynomials in the unknown a, the desired solution is found by solving the equation

$$\gcd(f(a), g(a)) = 0.$$

Applying Euclid's Algorithm again,

$$\begin{aligned} 0 &= \gcd(f(a), g(a)) \\ &= a^2 - 2a - 3 \\ &= (a+1)(a-3). \end{aligned}$$

Thus the values of a that make $R(x) = 0$ are -1 and 3.

Solution *by the proposer.*

Let

$$A(x) = x^{15} + 27x^3 + 688x^2 - 1352x - 1092$$

and

$$B(x) = x^2 - x + a.$$

If $x = 0$, then a must divide 1092. If $x = 1$, then a must divide 1728. since $\gcd(1092, 1728) = 12$, a must be limited to $\pm1, \pm2, \pm3, \pm4, \pm6, \pm12$. Consider $x = -4$. Then $a+20$ must divide $A(-4) = -1,073,728,228 = -2^2 \cdot 17 \cdot 19 \cdot 23^2 \cdot 1571$. Only $a = -3, -1, 3$ yield divisors of $A(-4)$. Consider $x = -3$. Then $a + 12$ must divide $A(-3) = -14,340,480 = -2^7 \cdot 3 \cdot 5 \cdot 7 \cdot 11 \cdot 97$. Only $a = -1, 3$ yield divisors of $A(-3)$. Thus $a = -1, 3$ is the desired solution.

Using polynomial division, we have

$$\begin{aligned} & x^{15}+27x^3+688x^2-1352x-1092 \\ = & \left(x^2-x-1\right) \\ & \cdot\left(\begin{array}{c} x^{13}+x^{12}+2x^{11}+3x^{10}+5x^9+8x^8+13x^7+21x^6 \\ +34x^5+55x^4+89x^3+144x^2+260x+1092 \end{array}\right) \end{aligned}$$

and

$$\begin{aligned} & x^{15}+27x^3+688x^2-1352x-1092 \\ = & \left(x^2-x+3\right) \\ & \cdot\left(\begin{array}{c} x^{13}+x^{12}-2x^{11}-5x^{10}+x^9+16x^8+13x^7-35x^6 \\ -74x^5+31x^4+253x^3+160x^2-572x-364 \end{array}\right). \end{aligned}$$

Editor's Comment: Using the proposer's notation, note that $B(k) = B(1-k)$ for any integer k. Then $B(k)$ must divide $\gcd(A(k), A(1-k))$. For example, $B(5) = B(-4) = a + 20$ must divide $\gcd(A(5), A(-4)) = \gcd(30517590848, -10737282280) = 1748 = 2^2 \cdot 19 \cdot 23$. Since a must be limited to $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12$, only $a = -1$ and $a = 3$ satisfy this condition.

Problem 573. *Proposed by Pat Costello, Eastern Kentucky University, Richmond, Kentucky.*

A pair of numbers is called *amicable* if the sum of the proper divisors of the first number is equal to the second number and vice-versa. One way of constructing amicable pairs is to develop a "Thabit-Rule" which is just a set of values determined by a single input that need to be checked for primality. If all values turn out to be primes, they can be put together in some way to form an amicable pair.

Bill discovered the following "Thabit-Rule": if $p = 11 \cdot 2^n - 1$, $q = 2p - 1$, $r = 4p - 1$, and $s = (q+1)(r+1) - 1$ are all primes, then the numbers $2^{n+2}pqr$ and $2^{n+2}ps$ form an amicable pair. He was so excited because he quickly calculated that when $n = 2$, $p = 43$, which is prime. His excitement waned when he computed $q = 85$, which is not prime. He was very disappointed when it turned out that not all four of the values p, q, r, s are prime. Find an amicable pair using Bill's "Thabit-Rule", or show that none exists.

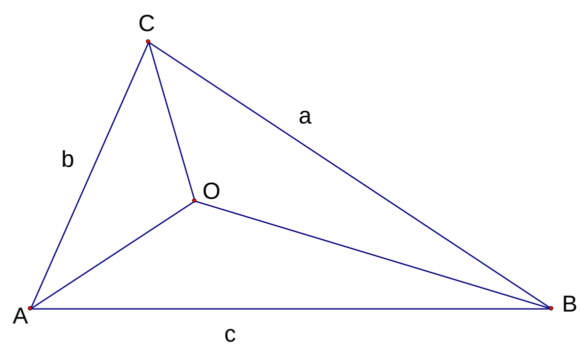
Since no solution has been received, this problem will remain open for another issue.

Problem 574. *Proposed by Thomas Chu, Austin, Texas.*

Evaluate

$$\left(OA^2 - OB^2\right)\left(OB^2 - OC^2\right)\left(OC^2 - OA^2\right)$$

in terms of sides a, b, c of the triangle ABC, where OA, OB, OC are the respective distances from the incenter O to the vertices of the triangle.



Solution *by Monica Erbacher, Heather Flay, and Erin Ross, jointly, students, SUNY Fredonia, Fredonia, New York.* (Revised slightly by the editor.)

Let O denote the incenter of triangle ABC. Then OA, OB, OC bisect $\angle BAC$, $\angle ABC$, $\angle ACB$, respectively. Let $\alpha = m\angle BAO = m\angle OAC$, $\beta = m\angle ABO = m\angle OBC$, and $\gamma = m\angle BCO = m\angle OCA$, where m denotes the measure of the given angle. By the Law of Cosines, and after rearranging, we obtain

$$OA^2 - OB^2 = c^2 - 2c(OB)\cos\beta \tag{6}$$

$$OA^2 - OC^2 = b^2 - 2b(OC)\cos\gamma \tag{7}$$

$$OB^2 - OC^2 = a^2 - 2a(OC)\cos\gamma \tag{8}$$

$$OB^2 - OA^2 = c^2 - 2c(OA)\cos\alpha \tag{9}$$

$$OC^2 - OA^2 = b^2 - 2b(OA)\cos\alpha \tag{10}$$

$$OC^2 - OB^2 = a^2 - 2a(OB)\cos\beta \tag{11}$$

Combining equations (1) and (4), we have

$$c = (OB)\cos\beta + (OA)\cos\alpha. \tag{12}$$

Similarly,

$$b = (OC)\cos\gamma + (OA)\cos\alpha \tag{13}$$

and

$$a = (OC)\cos\gamma + (OB)\cos\beta. \tag{14}$$

Combining equations (7), (8), and (9) yields

$$(OA)\cos\alpha - (OB)\cos\beta = b - a \tag{15}$$

$$(OB)\cos\beta - (OC)\cos\gamma = c - b \tag{16}$$

$$(OC)\cos\gamma - (OA)\cos\alpha = a - c. \tag{17}$$

Then from equations (1), (7), and (10), we have

$$OA^2 - OB^2 = c\,(OA\cos\alpha - OB\cos\beta) = c(b-a).$$

Similarly,

$$OB^2 - OC^2 = b(OC\cos\gamma - OA\cos\alpha) = b(a-c)$$

and

$$OC^2 - OA^2 = a(c-b).$$

Hence

$$\left(OA^2 - OB^2\right)\left(OB^2 - OC^2\right)\left(OC^2 - OA^2\right) = abc(b-a)(c-b)(a-c).$$

Also solved by Scott H. Brown, Auburn University, Montgomery, Alabama; Ovidiu Furdui, Western Michigan University, Kalamazoo, Michigan; and the proposer.

Reports of the Regional Conventions

Report of the North Central Regional Convention

The KME North Central Regional Convention was held April 16-17, 2004 at Emporia State University in Emporia, Kansas. 70 people attended from 11 different chapters in 3 states. The host chapter was Kansas Beta. Seven student papers were presented, with awards going to the top three papers. The award winners were A History of Mathematics in Ancient Egypt and Babylon by Cindee Calton (Iowa Alpha), An Investigation of Spiral Length by Fred Hollingshead, (Kansas Delta) and Chaotic System and Chua's Circuit by Dao Tran (Missouri Alpha). Conference attendees participated in a lateral thinking activity during the luncheon.

Report of the Southeastern Regional Conventions

Two conventions were held in our region this year. The first was held April 2–3, 2004, hosted by Virginia Alpha at Virginia State University in Petersburg. The second was held April 23–24, 2004, hosted by Tennessee Gamma at Union University in Jackson.

The Virginia convention featured faculty and students from the host chapter, as well as faculty from Niagara University NY Eta, Evangel University MO Theta, and Union University TN Gamma. The convention began with a local chapter initiation ceremony and a talk by Henry P. Johnson of Virginia Commonwealth University, followed by a presentation of the local chapter's new website and a mixer. The next day, student talks were given by Elecia Ridley and Luisa Soaterna; Ms. Soaterna won the best paper prize. Two faculty talks by Bryan Dawson and Don Tosh rounded out the morning's activities. A banquet was held at noon and featured an address by William Hawkins, Jr., director of the MAA's SUMMA program. The meeting concluded with an awards ceremony.

The Tennessee convention featured students and faculty from the host chapter TN Gamma, Texas Woman's University TX Gamma, and a prospective chapter at Lee University, as well as a faculty member from Evangel University MO Theta. The convention began with a mixer Friday evening. Four student presentations were given on Saturday, by Nikki Vassar, Brian A. Taylor, Allen Smith, and Kolo E. Goshi. The best paper prize was awarded to Mr. Goshi, of TN Gamma. A banquet was held at noon and featured the maintainer of the web's most popular prime number site, Chris Caldwell of the University of Tennessee at Martin. The meeting concluded with an awards ceremony, in which TN Gamma chapter president Nikki Vassar was commended for her exceptional work planning the convention.

Kappa Mu Epsilon News

Edited by Connie Schrock, Historian

Updated Information as of August 2004

News of chapter activities and other noteworthy KME events should be sent to

Connie Schrock, KME Historian
Mathematics Department
Emporia State University
1200 Commercial Street
Campus Box 4027
Emporia, KS 66801
or to
schrockc@emporia.edu

Chapter News

AL Alpha - Athens State University

Chapter President – Kristy Howard. 30 Actives, 7 New Members

Other spring 2004 officers: Angela Odom, Vice President; Sarah Justice, Secretary; Patrick Jones, Treasurer; Dottie (Fuller) Gasbarro, Corresponding Secretary.

Along with the members of the Math and Computer Science Club (MACS), KME members helped work the MACS booth at Club Day on the grounds of Athens State University, Athens, AL in April of 2004. Refreshments were served and many ASU students met the officers and members of KME and MACS.

New Initiates: Jill Allen, Laura Beth Gilbert, Kristy Howard, Patrick Jones, Sarah Justice, Margaret Lohse, Angela Odom.

AL Zeta-Birmingham Southern

Chapter President – Wes Brown. 15 Actives, 7 New Members

Other spring 2004 officers: Mikel Wijayasuriya, Secretary; Sara Gaskin, Treasurer; Mary Jane Turner, Corresponding Secretary.

The Alabama Zeta chapter of KME at Birmingham Southern College held its spring meeting and initiation on March 9, 2004. There were six new members initiated. Later in the term, one additional member was initiated. The total membership for this year is 20 students and 2 faculty.

New Initiates: Mary Ferguson, Jason Kramer, Stephen Nolen, Johannes Norrell, Cardona Orozco, David Whitten, Matthew Woods.

CA Epsilon-California Baptist University

Chapter President – Jeffrey R. Mulari

Other spring 2004 officers: Derek Imai, Vice President; Tawni L Covington, Secretary; Holly Curran, Treasurer; Catherine Kong, Corresponding Secretary.

Our chapter hosted "Math ShowCase" at CBU on March 4, 2004. Students' math projects were displayed, home schooled children were invited to come on campus to have some math fun activities hosted by our KME and Math Club students. We also had our KME banquet and induction on April 1, 2004. Finally, we have a pizza/games/movie night on April 22, 2004.

CT Beta-Eastern Connecticut State University

9 New Members

An initiation ceremony was held May 1, 2004. The following individuals were initiated:

Robert Bowers, Keira Mazy, Shanielle Danner, Marlena Scialla, Olinda LaBeef, Chrystal Urbani, Laura Waz, Brian Whitehead, and Amy Bedner.

GA Alpha-State University of West Georgia

Chapter President – Heather Morse. 16 Actives, 15 New Members

Other spring 2004 officers: Sarah Bkair, Vice President; David Yarbrough, Secretary; Jill Copeland, Treasurer; Dr. Joe Sharp, Corresponding Secretary.

On April 21, 2004, the Georgia Alpha Chapter of KME held its 30^{th} initiation service at which 15 new members were initiated into KME bringing the total membership of Georgia Alpha to 287. After the initiation ceremony, chapter officers for 2004-2005 were elected as were listed above and a reception was held in honor of the 2004 initiates.

New Initiates: Sarah Blair, Derek Brown, Darrell Brown, Ryan Browning, Khrysti Cash, Jill Copeland, Jessie Gardner, Nesha Hyatt, Ginger Jones, Heather Morse, Jennifer Payne, Thomas Riley, Heather Smith, Doerian Waddle, David Yabrough.

GA Delta-Berry College

Chapter President – Jacqueline Black. 20 Actives, 10 New Members

Other spring 2004 officers: Byron Schunemann, Vice President; Matt Leonard, Secretary; Carrie Carden, Treasurer; Ron Taylor, Corresponding Secretary.

IA Alpha-University of Northern Iowa

Spring 2004 officers: Mark Ecker, Corresponding Secretary

New Initiates: Andrew Berns, Emily Borcherding, Lynne Dieckman, Erin Dieckman, Krista Dilger, Ryan Dunkel, Jake Ferguson, Doug Hoffman, Moonho Lee, Miki Mead, Dr, Marius Somodi.

IA Delta-Wartburg College

Chapter President – Angela Kohlhaas. 38 Actives, 10 New Members

Other spring 2004 officers: Nicholas Wuertz, Vice President; Kristin Granchalek, Secretary; Ben Brady, Treasurer; Dr. Brian Birgen, Corresponding Secretary.

We continued our regular card night meetings, although attendance was down from Fall semester. We encouraged a number of students to attend the Iowa Sectional Meeting of the Mathematical Association of America, where they participated in the annual Mathematics Competition. We planned the annual banquet and initiation ceremony, which was held on March 20; ten members were initiated. In May, there was a service project in the library, in which we reviewed the books in the reference section and removed the math books which were no longer worth keeping (logarithm and trigonometric tables and such). Our annual end of the year picnic was held on May 18.

New Initiates: Danielle Berg, Benjamin Brady, Karen Connelly, Jade Holst, Daisy Ndiva, James Rogers, Jeese Sathre, Tomoko Shibuya, Mahmoud Almanassra, Richard Chilcoat.

IL Delta-University of St. Francis

Spring 2004 officers: Richard Kloser, Corresponding Secretary.

New Initiates: Jason Allen, Katherine Blotnik, Roy Broderick, Melanie Choate, Raymond Halper, Lavon Harold, Susan Markun, Matthew McCarthur, Tina Middleton, Katherine Phillips, Laura Russell, Warren SanLuis, John Schlee.

IL Theta-Benedictine University

Spring 2004 officers: Lisa Townsley, Corresponding Secretary.

New Initiates: Anthony DeLegge, Daniel Good, Andrew Keen, Heather Luzadder.

IL Zeta-Dominican University

Chapter President – Jen Soldat. 30 Actives, 9 New Members

Other spring 2004 officers: Merrit DeBartolo, Vice President; Kathrina Parkhill, Secretary; Maria Guzman, Treasurer, Marion Weedermann, Corresponding Secretary.

The Illinois Zeta chapter of KME completed many activities during the spring semester, including:

◇ Clothing Sale – 15 members ordered clothing. The design was developed by one of our own, Gary Satko.

◇ Pi-Day – On March 16, 2004 we sponsored our annual Pi-Day in the Social Hall. We received $250 of financial backing for this event from Campus Activities (CAB). The event was part of the campus-wide Spring Fling Week. We distributed over 20 pies to the Dominican community, in hopes to bring about some math awareness, and also to bring the community together.

◇ Induction – On March 21, 2004 we hosted our annual induction ceremony at the Priory Auditorium. The speaker for this year's event was Arthur Guetter, Prof. of Math. from Hamline University. For the first time this year, the new initiates also played a simplified version of "Who wants to be a mathematician". The event was very well attended by many current members of KME who helped make this induction a great success.

◇ Election of new officers – On April 22, 2004 we held the last KME-meeting to bring together our old and new members. During the meeting we solicited nominations for new officers for the next year. Of the three nominees, two were elected to become KME officers.

◇ End-of-the-year party – Our annual potluck party on April 25^{th} was a welcome study break for many students.

◇ Cheesecake Fundraiser – On April 29, 2004 we hosted our first-ever fundraiser. We raised over $100 for events during the next academic year.

◇ Blackboard site – We have created a Blackboard site that can be accessed by all members of our chapter. We have used this site for announcements and held anonymous officer elections.

IN Beta-Butler University

Chapter President – Christine Berkesch 16 Actives

Other spring 2004 officers: Jennifer Thompson, Vice President; Jennifer Legge, Secretary; Clint Garrett, Treasurer; Amos Carpenter, Corresponding Secretary.

In addition to our monthly meetings, we brought two invited speakers to campus: *The Geometrical Puppet Show* presented by George Francis, Ph.D. and *Image Restoration* presented by Bryan Lewis, Ph.D.

IN Delta-University of Evansville

Spring 2004 officers: Joanne Redden, Corresponding Secretary.

New Initiates: Sarah Bockting, Anthony Byrum, Angela Elsten, Blake Emery, Drew Flamion, Jessica Frisz, Melissa Giles, Mandir Helms, Joseph LaHue, Kathleen Malone, Meagan McKiney, Melissa Miller, Rebekah Musselwhite, L. Morgan Oberle, Zach Page, Matthew Phillips, Michael Sanders, Nicholas Weyer, Alan Wilber.

KS Beta-Emporia State University

Chapter President – Melinda Born. 24 Actives, 5 New Members

Other spring 2004 officers: Leah Childers, Vice President; Chris Dobbs, Secretary; Raegen Dyro, Treasurer; Connie S. Schrock, Corresponding Secretary.

KS Beta chapter of KME hosted the Regional Conference. Much time and energy was put into the project. Many of the members helped with the Mathematics Family night at the middle school and at a conference held on campus for middle level girls called " Expanding Your Horizons."

KS Delta-Washburn University

Chapter President – Zeb Kramer. 25 Actives, 4 New Members

Other spring 2004 officers: Jan Misak, Vice President; Jeff Kingman, Secretary/Treasurer; Kevin Charlwood, Corresponding Secretary.

The Kansas Delta chapter of KME met for three luncheon meetings with the Washburn Math club during the semester. Speakers and/or mathematics presentations were part of the meetings. Students Carolyn Cole, Zeb Kramer, Fred Hollingshead, Jo Marie Rozzelle, and Jan Misak accompanied faculty Kevin Charlwood, Mike Mosier and Al Riveland to the Regional Convention graciously hosted by Kansas Beta at Emporia State University in April. Fred Hollingshead earned a Top-3 award for presentation of his paper "An Investigation of Spiral Length." Newly elected chapter officers for the 2004-2005 academic year are President – Fred Hollingshead, Vice President – Jo Marie Rozzelle, Secretary/Treasurer – Jan Misak. The new Corresponding Secretary will be Kevin Charlwood.

KS Epsilon-Fort Hays State University

Spring 2004 officers: Jeffrey Sadler, Corresponding Secretary.

New Initiates: Jessica Joseph, Jennifer Princ.

KS Gamma-Benedictine College

Chapter President – Massimo Botta. 15 Actives, 6 New Members

Other spring 2004 officers: Christina Hoverson, Secretary; Andrea Archer, Treasurer; Linda Herndon, OSB, Corresponding Secretary.

The Kansas Gamma chapter welcomed six new members on February 18. After the initiation ceremony, we enjoyed dessert while watching some clips from a mathematics video. The evening concluded with having our chapter picture taken for the college yearbook. Throughout the spring semester KME members kept busy helping to host candidates who were on campus interviewing for positions in the department. Sister Jo Ann Fellin and Eric West represented our chapter at the regional KME meeting. Approximately thirty alumni members of Kansas Gamma, including current and retired faculty members, attended the retirement party for Sister Jo Ann Fellin on April 23 sponsored by the Department of Mathematics and Computer Science. We concluded the spring semester with a picnic held at the home of Richard Farrell, Emeritus Professor, where we honored all our department graduates.

KY Alpha-Eastern Kentucky University

Spring 2004 officers: Patrick Costello, Corresponding Secretary.

New Initiates: Laura Abney, bobby Adkins, Robert Bassett, Richard Bunce, James Cash, Erica Cepietz, Jenna Dovyak, Jennifer Fairchild, Holly Hatton, Mark Horsley, Joshua Hoskins, Mark Jackson, Crystal Meek, Sondra O'Canna, Wendi Pekoc, Tracie Prater, Shane Redmond, Brian Riddle, Alexandra Schrimpe, Justin Schriver, Christa Scopa, Tim Shipp, Garry Snowden.

KY Beta-Cumberland College

Chapter President – Matthew Rasure. 36 Actives, 14 New Members

Other spring 2004 officers: Stephanie Isaacs, Vice President; Justin Williams, Secretary; Vito Wagner, Treasurer, Jonathan Ramey, Corresponding Secretary.

On February 20, 2004, the Kentucky Beta chapter held an initiation and a joint banquet with Sigma Pi Sigma, physics honor society, at the Atrium. Kappa Mu Epsilon inducted fourteen new student members at the banquet, presided over by outgoing president, Matthew Rasure. As an additional feature, senior awards were given by the department at the banquet.

Jointly with the Mathematics and Physics Club, the Kentucky beta chapter hosted Dr. Carroll Wells from David Lipscomb University on April 15. He spoke on Fibonacci numbers and the Gold Ratio. On April 16, members also assisted in hosting a regional high school math contest, held annually at Cumberland College. On April 30, the entire department, including the Math and Physics Club, Sigma Pi Sigma, and the Kentucky Beta chapter held the annual spring picnic/cookout in Dr. Ramey's backyard.

LA Delta-University of Louisiana at Monroe

Chapter President – Aaptha Murthy. 18 Actives, 13 New Members

Other spring 2004 officers: Katie Roussy, Vice President; April Jeffcoat, Secretary; Sharee Davis, Treasurer; Serpil Saydam, Corresponding Secretary.

The Lousiana Delta Chapter of KME met five times during the spring semester. We had four pizza/picnic socials (some held jointly with the computer science student organization ACM), and we inducted eight students and five faculty members into KME in March. Several of our members have been very active in mathematics-related activities during the spring semester. Mathias Isaksson presented his undergraduate research project "Deep Graphs" (faculty mentor: Dr. Andrew J. Hetzel) both at the joint national meeting of the AMS and MAA in January and at the University of Louisiana at Monroe's Research Symposium in April. April Jeffcoat and Jay Liew also presented their joint undergraduate research project "On the Probability that a Matrix is Diagonalizable" (faculty mentor: Dr. Andrew J. Hetzel) both at the joint national meeting of the AMS and MAA and at the University of Louisiana at Monroe's Research Symposium.

Chapter president Aaptha Murthy presented her undergraduate research project "Best Choices for Keys in Certain RSA Applications" (faculty mentor: Dr. Annela Kelly) both the MAA regional meeting in Hammond, Louisiana in March and at the University of Louisiana at Monroe's Research Symposium in April. In addition, Aaptha and Jay participated in a team mathematics competition at the MAA regional meeting. Mathias and Aaptha were named co-winners of the Kelly Mathematics Award for undergraduate research, and Aaptha was named the top senior in mathematics at the University of Louisiana at Monroe. Aaptha, April, and Jay each graduated in May along with KME members Patrick Pyle and Katie Roussy. This fall, Aaptha will be pursuing a doctorate in financial mathematics at the University of Maryland, Baltimore County. April will be pursuing a doctorate in pharmacy administration at the Louisiana at Monroe, and both Patrick and Katie will be in graduate school.

MA Alpha-Assumption College

Chapter President – Kathryn Fleming. 10 Actives, 9 New Members

Other spring 2004 officers: Christine Elkinson, Vice President; Rebecca Freyenhagen, Secretary; Charles Brusard, Corresponding Secretary.

Nine new members were initiated at a chapter meeting held on April 30, 2004. New chapter officers were also elected.

New Initiates: Christine Elkinson, Kathryn Fleming, Rebecca Freyenhagen, Terri Hess, Willis Martin IV, Daniel Moran, Lauren Simpson, Rachel Smith, Matthew Wentworth.

MD Beta-McDaniel College

Chapter President – Jessica Bradford. 24 Actives, 0 New Members

Other spring 2004 officers: Shannon Pusey, Vice President; Kristie Springston, Secretary; Christopher Todd, Treasurer; Linda Eshleman, Corresponding Secretary.

With 31 members and an enthusiastic group of officers, this was a very active year for the Maryland Beta chapter. We sponsored: "Rook Theory" by an alumnus Fred Butler, Ph.D. – candidate at the Univ. of Pennsylvania, "Finite Fields" by Charlie Poole, Mathematician at the National Security Agency, "Infinite Games" by alumnus Dr. Dan Seabold, "Estimation Theory" by Dr. Bert Bradford, Applied Mathematician for Lockheed Martin. We also had several "pizza, problems, and ping pong nights" for math majors and sponsored senior honors presentations by two of our officers, the President and the Treasurer. Our group also had a career night dinner for math majors with 3 alumni members talking about careers in mathematics and other related fields, a bake sale at Homecoming as a money-raising event, a spring induction of new members, and finally an end of the year picnic for all math majors.

MD Delta-Frostburg State University

Chapter President –Matthew Miller. 30 Actives, 8 New Members

Other spring 2004 officers: Chris Smoot, Vice President; Sherry Hartman, Secretary; Dustin Robinson, Treasurer; Mark Hughes, Corresponding Secretary.

The Maryland Delta Chapter had an organization meeting in February where we planned for fundraisers to be held in March. These fundraisers were quite successful. About $80 was raised at our Pi Day bake sale. Several members worked hard to prepare the goodies, among them Sherry Hartman (our chapter Secretary) and Nazanin Tootoonchi. Also during March about $80 was collected from a candy Easter egg sale (the eggs having been provided by the mother of member Ted Langan). Officers for the upcoming school year were elected during our April meeting. Matt Miller will be continuing as President, Chris Smoot as Vice President, Greg Barnhart as Treasurer and Chris Smoot as Secretary. Chris Smoot provided an interesting lecture on Riemann Surfaces during our May meeting. This lecture was the culmination of Chris's independent study on this topic supervised by Dr. Mark Hughes.

MI Delta-Hillsdale College

Chapter President – Michael Nikkila. 14 Actives, 6 Faculty

Other spring 2004 officers: Joel Clark, Vice President; Erin Bartee, Treasurer; Dr. John H. Reinoehl, Corresponding Secretary.

The Delta Chapter of Michigan offers a free tutoring program for mathematics students.

New Initiates: Christin Alford, Joel Clark, Jared Light, Jessie Miller, Jasmine Spady, Shannon Stanglewicz.

MI Epsilon-Kettering University

Chapter President –Lynette Fulk (A) / Scott Porter(B). 192 Actives, 36 Faculty (2 Sections)

Other section A (winter 04/spring 04) *officers: Gayle Ridenour, Vice President; Kathleen Monfore, Secretary; George Hamilton, Treasurer.*

Other section B (winter 04/spring 04) *officers: Julie Xiong, Vice President; Kelly Wheaton, Treasurer; Justin Via, Secretary;* Corresponding Secretary*: Boyan Dimitrov, Corresponding Secretary.*

Winter 2004 (A Section):

There was a pizza party/movie was held on Feb. 12 at noon break. The movie was "Isaac Newton. The Gravity of Genius". The initiation ceremony for our new KME members was held on Feb. 27 at 6:30 p.m. in the McKinnon Theatre in the Academic building, and continued with a dinner in the Sunset room of the Kettering cafeteria. The keynote lecturer Jeff Buero, a former Kettering Applied Mathematics graduate, talked about

"The Mathematics of Bowling Scores". Jeff is just another example of a prosperous student who graduated Applied Mathematics and continued in his co-op workplace as actuary expert. Membership cards and pins, and the KME brochure were distributed to the new members.

Spring 2004 (B Section):

For the spring term of 2004 the students and KME members got together for a movie and sandwiches on May 10 in McKinnon Theatre at 7 p.m. The movie "Infinity" tells a story of the early life of genius and Nobel Prize winning physicist Richard Feynman. The initiation ceremony for the new members of Section B students was held on May 21, at 6 p.m. in Room A of the Campus Center. This is the place where the Kettering Executive Council usually holds its meetings. We welcome 37 new members to our chapter of KME. The keynote speaker was Professor Darrell Schmidt from Oakland University, who told us "A Cooling System Problem and Related Stories." Everything around is related to the car industry, and such topics are a frequent part of our everyday discussions.

For more information, please see our website at:
http://www.kettering.edu/acad/scimath/appmath/
MI Epsilon Chapter can also be found at: *http://www.kettering.edu/~kme/*

MO Alpha-Southwest Missouri State University

Chapter President – Jennifer Pope. 37 Active Members, 7 New Members
Other spring 2004 officers: Shawn Poindexter, Vice President; April Williams, Secretary; Michael Sallee, Treasurer; John Kubicek, Corresponding Secretary.

For the spring 2004 semester, the Missouri Alpha Chapter held a monthly meeting at which we had presentations by three faculty members and two students. The faculty sponsor and two students attended the Regional convention at Emporia State University. Dao Tran's presentation at the convention was recognized as one of the top papers.

MO Epsilon-Central Methodist College

Spring 2004 officers: Linda O. Lembke, Corresponding Secretary.

New Initiates: Kristofferson Culmer, John Millard, Jessica Brewer, Shaun Fanger, Derek Medlock.

MO Gamma-William Jewell College

New Initiates: Patrice Horton, Larry Turner, Jessica Burt.

MO Iota-Missouri Southern State University

Spring 2004 Officers: Chip Curtis, Corresponding Secretary.

New Initiates: Shiloh Burchfield, Michael Burns, Tom Campbell, Holly Elbert, David Lightle, Jeremy Mallory, Byron Mayfield, Sterling Moss, Dean Muse, Mudit Pachauri, Jenny Peters, Matthew Thompson, Jeremy Vacck.

MO Lambda-Missouri Western State College

Chapter President – Amy Lynn Kerling. 40 Actives, 18 New Members

Other spring 2004 officers: Gabe Wishnie, Vice President; Nicholas Limle, Secretary; James Blevins, Treasurer; Don Vestal, Corresponding Secretary.

MO Theta-Evangel University

Chapter President – Kevin Reed. 12 Actives, 10 New Members

Other fall 2003 officers: Nicolas Thompson, Vice President; Don Tosh, Corresponding Secretary.

We continued to have our monthly meetings. In February we elected new officers and initiated 10 new members. In April, Dr. Tosh and 11 students attended the regional convention in Emporia, Kansas.

MS Alpha-Mississippi University for Women

Chapter President – Shannon McVay. 13 Actives, 4 New Members

Other spring 2004 officers: Henry Boateng, Vice President; Amy Ladner, Secretary; Sarah Sheffield, Treasurer; Dr. Shaochen Yang, Corresponding Secretary.

The Mississippi Alpha chapter of KME had a busy spring semester full of activities, including: a monthly meeting on February 9, Starkville Community Theatre "Proof" activity on February 21, initiation on February 23, monthly meeting and elections on April 19, and a dinner night on April 22.

MS Gamma-The University of Southern Mississippi

Spring 2004 officers: Jose Contreras, Corresponding Secretary.

New Initiates: Patrice Horton, Larry Turner, Jessica Burt, Kathryn Robinson, Lenton McLendon, Jr.

MS Epsilon-Delta State University

Chapter President – Laura Wallace. 9 Actives, 5 New Members

Other spring 2004 officers: Frank Rice, Vice President; Amy Rowe, Secretary/Treasurer; Paula A. Norris, Corresponding Secretary.

NE Delta-Nebraska Wesleyan

Chapter President – Brad Randazzo. 19 Actives, 4 New Members

Other spring 2004 officers: Nicole Heath, Vice President; Jennifer Choutka, Secretary/Treasurer; Melissa Erdmann, Corresponding Secretary.

NJ Gamma-Monmouth University

Chapter President – Paul Zoccali. 52 Actives, 21 New Members

Other spring 2004 officers: Jessica Gregory, Vice President; Catharine Russmano, Secretary; Toni Festa, Treasurer; Lauren Kovacs, Historian, Lauren Grobelny and Lisa Marchalonis, Junior Liaisons; Judy Toubin, Corresponding Secretary

Last year NJ Gamma chapter was again involved in the soda tab collection for the Ronald McDonald House Charity. We were involved with a "pennies to dollars" fundraiser which helped our organization greatly. We hosted a talk by one of our professors on an interesting mathematics topic. Some of our members also participated in some charity work to help clean up the area.

NM Alpha-University of New Mexico

Spring 2004 officers: Pedro Embid, Corresponding Secretary.

New Initiates: Devaraj Aran, Doreen Barela, Stephen Bauer, Michael Bermudez, David Boutte, Adrian Chavez, Rob Clerx, Lauren Clevenger, Michelle Costa, David Gibson, Lorena Guiterrez, Heena Lakhani, James Lucero, Mandengue Mandengue, Paul Martin, Edward Matteo, William Muirhead, Mark Murmer, Christina Olcott, Kara Peterson, Paul Renfro, Chuck Vecere.

NY Alpha-Hofstra University

Chapter President – Andrew Lazowski. 33 Actives, 10 New Members

Other spring 2004 officers: William Harney and Daniel Lang, Vice Presidents; Jacqueline Jacobs and Ronald Giarraffa, Secretaries; Elizabeth Russell, Treasurer; Aileen Michaels, Corresponding Secretary.

We, students and faculty, visited The American Museum of National History, including the Rose Center for Earth and Space. At the Hayden Planetarium we saw "Passport to the Universe". We got together for dinner at the end of the semester.

NY Eta-Niagara University

Chapter President – Michelle Searles. 25 Actives, 13 New Members

Other spring 2004 officers: Matthew Nethercott, Vice President; Megan Zdrojewski, Secretary; Michael Bidzerkowny, Treasurer; Robert Bailey, Corresponding Secretary.

Following our spring 2004 induction in March, Dr. William Price presented a program dealing with magic and mathematics which was well received by all present.

NY Kappa-Pace University

Chapter President – Matthew Buco & Jonathan Tom. 20 Actives, 6 New Members

Other spring 2004 officers: Geraldine Taiani, Corresponding Secretary.

Our induction took place on May 4, 2004 at Pace University. New inductee, Prof. Robert Donley, gave a talk on "Rotations". Dinner followed at T. J. Brynes' at 77 Fulton St. in lower Manhattan.

NY Lambda-C.W. Post Campus of Long Island University

Chapter President – Michelle Rivera. 19 Actives, 11 New Members

Other spring 2004 officers: Justin McKinney, Vice President; Kira Adel, Secretary; Lisa Cook, Treasurer; Dr. Andrew M. Rockett, Corr. Sec.

Eleven students were initiated into the New York Lambda Chapter by the chapter officers during our annual banquet at the Greenvale Town House restaurant on the evening of April 15^{th}, bringing the chapter membership to 246. After initiation, Mr. Kevin O'Reilly's talk on *Halfway to Retirement and Still Learning* combined humorous remembrances with insights into effective education. Mr. O'Reilly is chairman of the mathematics departments of the middle and high schools in the Seaford Union Free School District. He received his B.A. *summa cum laude* (1989) and M.S. (1991) from C.W. Post and is member number 65 of our chapter. Our evening concluded with the presentation by Dr. James V. Peters of MAA students memberships to Xiaochun Li, Henry Ciapas, and Joseph Ruggiero; the announcement of the 2003-2004 departmental awards: the *Claire F. Adler Award* and the *Lena Sharney Memorial Award* to Joseph Ruggiero, and the *Hubert B. Huntley Memorial Award* to Jennifer Flynn; and the announcement by Dr. Maithili Schmidt-Raghavan of the *Dean Schmidt Scholarship Award* to Laura Silverman and the *Dean Schmidt Graduate Scholarship Award* to Xiaochun Li.

NY Nu-Hartwick College

Chapter President – Jennifer Slade. 25 Actives, 15 New Members

Other spring 2004 officers: Ezekiel Miller, Vice President; Muhammed Qadi, Secretary; Dannae Pasculli, Treasurer; Ron Brzenk, Corr. Sec.

New Initiates: Josephine Greco, Shirley Humphrey, Peter Noon, Helen Norton, Maher Awartani, Justine Beck, Karen Ceberek, Ahmed Farooq, Adam Frys, Cylon George, Rasha Jawabri, Qi Liao, Elizabeth McCabe, Dannae Pasculli, Muhammad Qadi, Jessica Radcliffe, Christine Rossi, Martin Svestoslavov, Nipen Wosti.

OH Alpha-Bowling Green State University

Spring 2004 officers: David Meel, Corresponding Secretary.

New Initiates: Leigh Ann Blankenship, Allison Brakefield, Anthony P. Calabrese, Barbara Collier, Kyle Falhaber, Ashley Fealy, Alisha Flores, Katherine Guldenschuh, Jeremy Joseph, Carrie Little, Erin McCollam, Christopher Plotts, Megan Schneider, Jason Seabold, Justin Shank, Martina Tayek, Andrew Wilhelm, Breanne Bennett, Jonathan Brackbill, Courtney Buckey, Stephanie Chalk, Gregory Hopkins, Jacob Johanssen, Chelsea Karr, Jaime Kohnen, Kelsen LaBerge, Kristine Patton, Eric Stockwell, Rchel Wechter, Michael Zimmermann.

OH Eta-Ohio Northern University

Spring 2004 officers: Donald Hunt, Corresponding Secretary.

OH Gamma-Baldwin-Wallace College

Chapter President – Thomas Kovacevich. 15 Actives, 28 New Members

Other spring 2004 officers: Tim Fijalkovich, Vice President; Lisa Fox, Secretary; Allison Hegedus, Treasurer; David Calvis, Corr. Sec.

OK Alpha-Northeastern State University

Chapter President – Miri Whisnant. 53 Actives, 12 New Members

Other spring 2004 officers: Carrie Hoffman, Vice President; Nick Jones, Secretary/ Treasurer; Dr. Joan E. Bell, Corresponding Secretary.

The spring 2004 initiation brought 12 new students into the Oklahoma Alpha chapter. We were pleased to have these speakers this semester: Dr. Hohan Kelkar, Chair of the Petroleum Engineering Deptartment at the University of Tulsa; Dr. Wendell Wyatt, Assistant Professor of Mathematics Education at Northeastern State University; and, Dr. Richard Redner, Professor. of Mathematical. Sciences and Associated. Dean of Research and Graduate Studies at the University of Tulsa.

The NSU Education Deptartment hosted the event Celebration of Teaching for middle and high school students interested in teaching. Our KME chapter hosted a booth to promote mathematics and Kappa Mu Epsilon. Gayle Farmer, Instructor in Mathematics and active member our chapter since 1988, retired this year. The end of the semester was celebrated with free ice cream floats for math faculty and students.

PA Alpha-Westminster College

Chapter President – Bradley Patton. 19 Actives, 8 New Members

Other spring 2004 officers: Lauren Beichner, Vice President, Thomas Spencer, Secretary; Amanda Ganster, Treasurer; Carolyn Cuff, Corresponding Secretary.

Pennsylvania Alpha sponsored an ice cream social in the fall to welcome back upperclassmen and welcome first year students to campus. We also worked with the other sciences in hosting the first annual Geek Week. Logic problems were created for teams to solve in the nightly competitions. We also sponsored a trip to Crytological Museum in Fort Meade Maryland and International Spy Museum in Washington D.C. At the Crytological Museum we arranged for a special talk on Boolean Algebra and a guided tour of the museum. Our group also helped to sponsor the mathematics and computer science recognition dinner for scholarship winners and graduating seniors and provided pizza during finals week.

New Initiates: Lauren Beichner, Crystal Buntman, Andrew Changoway, Rachel Donner, Brian Fadden, Amanda Ganster, Andrea Murphy.

PA Gamma-Waynesburg College

Spring 2004 officers: James Bush, Corresponding Secretary.

New Initiates: Stephen Ionadi, Kathleen Trimmer, David Kacsmarek.

PA Iota-Shippensburg University

Chapter President – Kristina Wile. 20 Actives, 2 New Members

Other spring 2004 officers: Christa Friewald, Vice President; Lauren Frazier, Secretary; Judith Canner, Treasurer; John Cooper, Corr. Sec.

This spring the KME chapter again helped to host the High School Math Contest held every spring at Shippensburg University.

PA Lambda-Bloomsburg University of Pennsylvania

Chapter President – Kate Wright. 42 Actives, 13 New Members

Other spring 2004 officers: Eric Brown, Vice President; Lisa Be

PA Nu-Ursinus College

Spring 2004 officers: Jeff Neslen, Corresponding Secretary.

New Initiates: Mark Heere, Raymond Kilargis, Adam Slavin.

PA Rho-Thiel College

16 Actives

The installation of the Pennsylvania Rho chapter took place on February 13, 2004 in the Lutheran Heritage Room at Thiel College, Greenville, Pennsylvania. 14 students and 2 faculty members formed the charter group, while approximately 40 family members, students, faculty and administrators were also in attendance. Taking part in the ceremony were officers of the Math Club at Thiel College, including Amanda McKeehan, President; Nicole Demski, Vice President; Melanie Henthron, Secretary; and Rebekah Williams, Treasurer. The installation was performed by Dr. Robert Bailey, KME National President, who also addressed the group on the history of Kappa Mu Epsilon.

Chapter officers will be appointed at a later date for the next school year. Dr. John Nicols will serve as Corresponding Secretary, and the Faculty Sponsor will be Dr. Karl Oman. A reception for those present followed the ceremony.

PA Theta-Susquehanna University

Spring 2004 officers: Carol Harrison, Corresponding Secretary.

New Initiates: Michael Cooper, Jadrien Deibler, Pamela Doehner, Christine Gunther, Brian Hixon, Jacki Jensenius, Katrina Konnick, Elizabeth Laub, Michael Lerch, Bryan Meier, Anuj Sainju, Bryan Strohl, Jenna Wallace, Jennifer Wilson, David Yaskewich.

SC Gamma-Winthrop University

Chapter President – Christine Jones. 10 Actives, 3 New Members

Other spring 2004 officers: Sean Rae, Vice President; Laura Trook, Secretary; Hannah Kolberg, Treasurer; Frank Pullano, Corresponding Secretary.

TN Delta-Carson-Newman College

Chapter President – Chris Anderson. 21 Actives, 5 New Members
Other spring 2004 officers: Johnny Harrison, Vice President; Sara Patton, Secretary; Holly Gragg, Treasurer; B.A. Starnes, Corresponding Secretary.

The Tennessee Delta chapter had a much more active year in 2003-2004. The new members were inducted at a ceremony in September at Perkins Restaurant in Jefferson City. Shortly thereafter, at the October meeting, officers were elected and ideas were exchanged. The chapter sponsored a team in the college quiz bowl in January. The team had a great run and finished in 2^{nd} place overall.

In April, following an aggressive recruiting campaign, five new members were inducted at the annual picnic at Cherokee Lake. After an interesting and intriguing speech by former faculty member Howard Chitwood, the club enjoyed hot dogs and hamburgers and then worked off the weight with a hard fought Lacrosse match between the faculty and students. The faculty prevailed 9-8 and a good time was had by all.

New Initiates: Philip Burger, David Bennett, Daniel Cate, Marsha Cox, Melissa Summey.

TN Epsilon-Bethel College

3 Actives. Spring 2004 officers: Russell Holder, Corresponding Secretary.

TN Gamma-Union University

Chapter President –Nikki Vassar. 16 Actives, 4 Associates
Other spring 2004 officers: Allen Smith, Vice President; Willie George, Secretary; Brian Taylor, Treasurer; Bryan Dawson, Corr. Sec.

The TN Gamma chapter held its annual initiation banquet April 22, 2004, at the Old Country Store. Ten students were initiated, from five different states and one foreign country. Union alum and former KME member Lindsey Crain Stephenson was the speaker. The highlight of the semester took place that same weekend, April 23-24, 2004, when the chapter hosted a regional convention. Four TN Gamma students presented papers, and one of them, new initiate Kolo "Sunday" Goshi, received the Best Paper Award. An end-of-year cookout, sponsored jointly with the local ACM student chapter, was held May 11, 2004 in The Grove on Union's campus. At that event many awards were announced, including next year's Joe Tucker scholarship recipient, Kevin Hieb, and the recipient of a new award for best undergraduate research in mathematics during the previous 12 months, Allen Smith.

New Initiates: Denise Baughman, David Criswell, Jennifer Ellis, Kolo Emmanuel Sunday Goshi, Kevin Hieb, Jonathan Kee, Kiera Knappman, Amanda Rainey, Kerstin Ure, Tony Winkler.

TX Eta-Hardin-Simmons University

Chapter President – Lynsey Mankins. 11 Actives, 10 New Members
Other spring 2004 officers: Melissa Schaeffer, Vice President; Mica Hill, Secretary/Treasurer; Frances Renfroe, Corresponding Secretary.

The 29^{th} annual induction ceremony for the Texas Eta chapter was held March 31, 2004. There were ten new members: Megan Campbell, Mica Hill, Stephanie Irwin, Lynsey Mankins, Melissa McClanahan, Aaron McLaughlin, Tava Peralta, Jessica Rieger, Stephanie J. Rollins, and Randall Volcko. With the induction of these members, membership in the local chapter stands at 243.

Leading the induction ceremonies were President Larry Smedley, Vice-President Katie Wooten, and Secretary Kerra LeBlanc. Following the induction ceremony, membership shingles and pins were presented to the 2003 inductees. KME then adjourned, and the members, inductees, and chapter sponsors enjoyed pizza and cold drinks.

TX Gamma-Texas Woman's University

Chapter President – Lindsay Renfro. 13 Actives, 8 New Members
Other spring 2004 officers: Melinda Smith, Vice President; Stephanie Arnold, Secretary; Marian Marvin, Treasurer; Dr. Mark S. Hamner, Corresponding Secretary.

The TX Gamma chapter has been very involved this past semester, including: meetings on January 28, February 13 and 26, March 31, and April 16 and 22, a formal induction of new members on February 2, bowling on February 7, a bake sale on February 24, KME spring picnic in honor of graduating seniors on April 17, and attendance by several members at the regional convention held in Jackson, Tennessee (April 23-24).

New Initiates: Stephanie Arnold, Danesh Chowritmootoo, Melinda Bowman, Lindsay Renfro, Teresa Jenkins, Marian Marvin, Chris Ledbetter, Robin Horton.

TX Kappa-University of Mary Hardin-Baylor

Chapter President – Jill Klentzman. 10 Actives, 5 New Members.
Other spring 2004 officers: Rona Greene, Vice President; Amanda Simmons, Secretary; Peter H. Chen, Corresponding Secretary.

New Initiates: Andrew Ellis, James Parten, Thomas Preston, Stacy Rosa, Julie Solomon.

TX Mu-Schreiner University

Chapter President – Shelly Stark. 8 Actives, 4 New Members
Other spring 2004 officers: Rebekha Collins, Vice President; Charmelyn Fortune, Secretary/Treasurer; William Sliva, Corresponding Secretary.

VA Delta-Marymount University

Spring 2004 officers: Elsa Schaefer, Corresponding Secretary.

New Initiates: Stephanie Cawthorne, Cynthia Cicalese, Judy Green, Eilani Gerstner, Joshua Gerstner, Kristin Ingalls, Vanessa Job, Tanya Kazakova, Arnetta Kelly, Mischel Kwon, Hien Phan, Lindsey Redding, Angela Rogers, Julie Rogers, Cathleen Seery, Atteq Sharfuddin, Ilana Stark, Elsa Schaefer, Anna Wolfram, Rachel Sybor.

VA Gamma-Liberty University

Spring 2004 officers: Glyn Wooldridge, Corresponding Secretary.

New Initiates: Kristin Colson, Jeffrey Crayton, Jennifer Elliott, Michael Floyd, Andrew Hampton, Michael Henrich, Ruth Holdbrook, Christopher Jarvis, Bibhuti Tamrakar, Dr. Timothy Van Voorhis.

WI Alpha-Mount Mary College

Spring 2004 officers: Abdel Nasar Al-Hasan, Corresponding Secretary.

New Initiates: Jacqueline Lucas, Charlotte Vasey, Clare Wesley.

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New Problem Corner Editor

This issue marks the start of a transition to a new editor of the Problem Corner of The Pentagon. Catherine Kong, of the California Epsilon chapter, California Baptist University, will gradually assume these duties. New problem proposals and solutions to problems from future issues should be addressed to:

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Dr. Kong will be the eighth editor of the Problem Corner. The Problem Corner was inaugurated with the Fall, 1947 issue. Previous Problem Corner Editors were Judson W. Foust, Central Michigan College of Education (1947-1952), Frank C. Gentry, University of New Mexico (1953-1957), J.D. Haggard, Kansas State Teachers College (1957-1963), F. Max Stein, Colorado State University (1964-1965), H. Howard Frisinger, Colorado State University (1966-1968), Robert L. Poe, Berry College (1968-1973). Kenneth M. Wilke began his duties as editor of the Problem Corner with the Fall, 1974 issue of The Pentagon, thirty years ago. He has thus served longer than all of the previous editors of the Problem Corner put togther. His dedication to Kappa Mu Epsilon has been truly remarkable. Thank you, Ken.

Active Chapters of Kappa Mu Epsilon

Listed by date of installation

Chapter	Location	Installation Date
OK Alpha	Northeastern State University, Tahlequah	18 April 1931
IA Alpha	University of Northern Iowa, Cedar Falls	27 May 1931
KS Alpha	Pittsburg State University, Pittsburg	30 Jan 1932
MO Alpha	Southwest Missouri State University, Springfield	20 May 1932
MS Alpha	Mississippi University for Women, Columbus	30 May 1932
MS Beta	Mississippi State University, Mississippi State	14 Dec 1932
NE Alpha	Wayne State College, Wayne	17 Jan 1933
KS Beta	Emporia State University, Emporia	12 May 1934
AL Alpha	Athens State University, Athens	5 March 1935
NM Alpha	University of New Mexico, Albuquerque	28 March 1935
IL Beta	Eastern Illinois University, Charleston	11 April 1935
AL Beta	University of North Alabama, Florence	20 May 1935
AL Gamma	University of Montevallo, Montevallo	24 April 1937
OH Alpha	Bowling Green State University, Bowling Green	24 April 1937
MI Alpha	Albion College, Albion	29 May 1937
MO Beta	Central Missouri State University, Warrensburg	10 June 1938
TX Alpha	Texas Tech University, Lubbock	10 May 1940
KS Gamma	Benedictine College, Atchison	26 May 1940
IA Beta	Drake University, Des Moines	27 May 1940
TN Alpha	Tennessee Technological University, Cookeville	5 June 1941
NY Alpha	Hofstra University, Hempstead	4 April 1942
MI Beta	Central Michigan University, Mount Pleasant	25 April 1942
NJ Beta	Montclair State University, Upper Montclair	21 April 1944
IL Delta	University of St. Francis, Joliet	21 May 1945
KS Delta	Washburn University, Topeka	29 March 1947
MO Gamma	William Jewell College, Liberty	7 May 1947
TX Gamma	Texas Woman's University, Denton	7 May 1947
WI Alpha	Mount Mary College, Milwaukee	11 May 1947
OH Gamma	Baldwin-Wallace College, Berea	6 June 1947
CO Alpha	Colorado State University, Fort Collins	16 May 1948
MO Epsilon	Central Methodist College, Fayette	18 May 1949
MS Gamma	University of Southern Mississippi, Hattiesburg	21 May 1949
IN Alpha	Manchester College, North Manchester	16 May 1950
PA Alpha	Westminster College, New Wilmington	17 May 1950
IN Beta	Butler University, Indianapolis	16 May 1952
KS Epsilon	Fort Hays State University, Hays	6 Dec 1952
PA Beta	LaSalle University, Philadelphia	19 May 1953
VA Alpha	Virginia State University, Petersburg	29 Jan 1955
IN Gamma	Anderson University, Anderson	5 April 1957
CA Gamma	California Polytechnic State University, San Luis Obispo	23 May 1958
TN Beta	East Tennessee State University, Johnson City	22 May 1959
PA Gamma	Waynesburg College, Waynesburg	23 May 1959
VA Beta	Radford University, Radford	12 Nov 1959
NE Beta	University of Nebraska—Kearney, Kearney	11 Dec 1959
IN Delta	University of Evansville, Evansville	27 May 1960

OH Epsilon	Marietta College, Marietta	29 Oct 1960
MO Zeta	University of Missouri—Rolla, Rolla	19 May 1961
NE Gamma	Chadron State College, Chadron	19 May 1962
MD Alpha	College of Notre Dame of Maryland, Baltimore	22 May 1963
CA Delta	California State Polytechnic University, Pomona	5 Nov 1964
PA Delta	Marywood University, Scranton	8 Nov 1964
PA Epsilon	Kutztown University of Pennsylvania, Kutztown	3 April 1965
AL Epsilon	Huntingdon College, Montgomery	15 April 1965
PA Zeta	Indiana University of Pennsylvania, Indiana	6 May 1965
AR Alpha	Arkansas State University, State University	21 May 1965
TN Gamma	Union University, Jackson	24 May 1965
WI Beta	University of Wisconsin—River Falls, River Falls	25 May 1965
IA Gamma	Morningside College, Sioux City	25 May 1965
MD Beta	McDaniel College, Westminster	30 May 1965
IL Zeta	Domincan University, River Forest	26 Feb 1967
SC Beta	South Carolina State College, Orangeburg	6 May 1967
PA Eta	Grove City College, Grove City	13 May 1967
NY Eta	Niagara University, Niagara University	18 May 1968
MA Alpha	Assumption College, Worcester	19 Nov 1968
MO Eta	Truman State University, Kirksville	7 Dec 1968
IL Eta	Western Illinois University, Macomb	9 May 1969
OH Zeta	Muskingum College, New Concord	17 May 1969
PA Theta	Susquehanna University, Selinsgrove	26 May 1969
PA Iota	Shippensburg University of Pennsylvania, Shippensburg	1 Nov 1969
MS Delta	William Carey College, Hattiesburg	17 Dec 1970
MO Theta	Evangel University, Springfield	12 Jan 1971
PA Kappa	Holy Family College, Philadelphia	23 Jan 1971
CO Beta	Colorado School of Mines, Golden	4 March 1971
KY Alpha	Eastern Kentucky University, Richmond	27 March 1971
TN Delta	Carson-Newman College, Jefferson City	15 May 1971
NY Iota	Wagner College, Staten Island	19 May 1971
SC Gamma	Winthrop University, Rock Hill	3 Nov 1972
IA Delta	Wartburg College, Waverly	6 April 1973
PA Lambda	Bloomsburg University of Pennsylvania, Bloomsburg	17 Oct 1973
OK Gamma	Southwestern Oklahoma State University, Weatherford	1 May 1973
NY Kappa	Pace University, New York	24 April 1974
TX Eta	Hardin-Simmons University, Abilene	3 May 1975
MO Iota	Missouri Southern State University, Joplin	8 May 1975
GA Alpha	State University of West Georgia, Carrollton	21 May 1975
WV Alpha	Bethany College, Bethany	21 May 1975
FL Beta	Florida Southern College, Lakeland	31 Oct 1976
WI Gamma	University of Wisconsin—Eau Claire, Eau Claire	4 Feb 1978
MD Delta	Frostburg State University, Frostburg	17 Sept 1978
IL Theta	Benedictine University, Lisle	18 May 1979
PA Mu	St. Francis University, Loretto	14 Sept 1979
AL Zeta	Birmingham-Southern College, Birmingham	18 Feb 1981
CT Beta	Eastern Connecticut State University, Willimantic	2 May 1981
NY Lambda	C.W. Post Campus of Long Island University, Brookville	2 May 1983
MO Kappa	Drury University, Springfield	30 Nov 1984
CO Gamma	Fort Lewis College, Durango	29 March 1985

NE Delta	Nebraska Wesleyan University, Lincoln	18 April 1986
TX Iota	McMurry University, Abilene	25 April 1987
PA Nu	Ursinus College, Collegeville	28 April 1987
VA Gamma	Liberty University, Lynchburg	30 April 1987
NY Mu	St. Thomas Aquinas College, Sparkill	14 May 1987
OH Eta	Ohio Northern University, Ada	15 Dec 1987
OK Delta	Oral Roberts University, Tulsa	10 April 1990
CO Delta	Mesa State College, Grand Junction	27 April 1990
NC Gamma	Elon College, Elon College	3 May 1990
PA Xi	Cedar Crest College, Allentown	30 Oct 1990
MO Lambda	Missouri Western State College, St. Joseph	10 Feb 1991
TX Kappa	University of Mary Hardin-Baylor, Belton	21 Feb 1991
SC Delta	Erskine College, Due West	28 April 1991
SD Alpha	Northern State University, Aberdeen	3 May 1992
NY Nu	Hartwick College, Oneonta	14 May 1992
NH Alpha	Keene State College, Keene	16 Feb 1993
LA Gamma	Northwestern State University, Natchitoches	24 March 1993
KY Beta	Cumberland College, Williamsburg	3 May 1993
MS Epsilon	Delta State University, Cleveland	19 Nov 1994
PA Omicron	University of Pittsburgh at Johnstown, Johnstown	10 April 1997
MI Delta	Hillsdale College, Hillsdale	30 April 1997
MI Epsilon	Kettering University, Flint	28 March 1998
KS Zeta	Southwestern College, Winfield	14 April 1998
TN Epsilon	Bethel College, McKenzie	16 April 1998
MO Mu	Harris-Stowe College, St. Louis	25 April 1998
GA Beta	Georgia College and State University, Milledgeville	25 April 1998
AL Eta	University of West Alabama, Livingston	4 May 1998
NY Xi	Buffalo State College, Buffalo	12 May 1998
NC Delta	High Point University, High Point	24 March 1999
PA Pi	Slippery Rock University, Slippery Rock	19 April 1999
TX Lambda	Trinity University, San Antonio	22 November 1999
GA Gamma	Piedmont College, Demorest	7 April 2000
LA Delta	University of Louisiana, Monroe	11 February 2001
GA Delta	Berry College, Mount Berry	21 April 2001
TX Mu	Schreiner University, Kerrville	28 April 2001
NJ Gamma	Monmouth University	21 April 2002
CA Epsilon	California Baptist University, Riverside	21 April 2003
PA Rho	Thiel College, Greenville	13 February 2004
VA Delta	Marymount University, Arlington	26 March 2004
NY Omicron	St. Joseph's College, Patchogue	1 May 2004
TX Nu	Texas A&M University - Corpus Christi, Corpus Christi	8 May 2004