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De Moivre's Theorem and its Corollaries

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1. Introduction

Even though mathematicians did not pay much attention to complex numbers before the 16th century, the history of complex numbers goes back two thousand years. It is really impossible to trace the exact origin of complex numbers because they were actually employed by mathematicians through many centuries without being properly understood or defined.

For many centuries mathematicians did not accept complex numbers as solutions; they just ignored them. The first problem recorded in a mathematical text that led to an imaginary number was $\sqrt{81 - 144}$, found in the book *Stereometrica* by Heron of Alexandria (20-60 A.D.). However, whether it was a mistake or not, he arrived at $\sqrt{63}$ instead of $\sqrt{-63}$. These are, of course, examples of not using complex numbers.

The Hindu mathematician Mahaviracarya (~850 A.D.) wrote:

As in the nature of things, a negative quantity is not a square quantity, and therefore, it has no square root.

By the middle of the 16th century, however, mathematicians began to think about equations such as $x^2 + 1 = 0$ and its solution set, $\pm\sqrt{-1}$. The Italian mathematician Gerolamo Cardano (1501-1576) called complex numbers “as subtle as they are useless,” but began to work on problems that involved the use of complex numbers.

Rene Descartes (1596-1650) was the first to use the terms “real” and “imaginary.” In 1777, the Swiss mathematician Leonard Euler (1707-1783) introduced the symbol i for $\sqrt{-1}$, as well as the notation $a + bi$ for a complex number. Englishman John Wallis (1616-1703) and the German mathematician Carl Friedrich Gauss (1777-1855) also contributed to the idea of

the complex plane, and in 1799, Caspar Wessel (1745-1818), a Danish-Norwegian mathematician, introduced a graphical representation of the complex numbers on the xy -plane. Gauss proved the Fundamental Theorem of Algebra which states that every algebraic equation has at least one root or solution in the set of complex numbers. The French mathematician Augustin Louis Cauchy (1789-1857) studied functions of complex numbers.

It was easily seen that the real numbers are deficient (or not closed), so that not all algebraic operations on them produce real numbers. Thus for $\sqrt{-1}$ to make sense, mathematicians had to consider the domain of complex numbers. The system of complex numbers is closed since the result of any algebraic operation performed on complex numbers will give another complex number.

2. De Moivre's and Euler's Theorems and Corollaries

Abraham De Moivre (1667-1754) was a French born mathematician who pioneered probability theory and the connection of complex numbers to trigonometry. Moving to England at an early age, he began teaching mathematics and reading Newton's book *Principia Mathematica* in his leisure, which inspired him to publish works such as *The Doctrine of Chances* (1718), *Miscellanea Analytica* (1730), and also to write numerous papers in the *Philosophical Transactions*. His most famous work is the theorem which bears his name. De Moivre discovered his theorem about the same time as it was discovered by Johann Lambert (1728-1777), a German mathematician. De Moivre and Lambert knew of each other's work, so they may have collaborated on it, but in any event, the theorem is named for De Moivre.

De Moivre's Theorem, which was never explicitly expressed in this form by him, states: If $z = \cos \theta + i \sin \theta$, then

$$z^n = (\cos \theta + i \sin \theta)^n = \cos n\theta + i \sin n\theta.$$

Although historically proved earlier, De Moivre's Theorem can easily be derived from Euler's formula

$$e^{i\theta} = \cos \theta + i \sin \theta,$$

and the exponential law

$$(e^{i\theta})^n = e^{i\theta n}.$$

These give

$$z^n = (\cos \theta + i \sin \theta)^n = (e^{i\theta})^n = e^{i(n\theta)} = \cos n\theta + i \sin n\theta,$$

proving De Moivre's Theorem. As a special case, Euler noted that, if

$n\theta = \pi$, then the result is the following:

$$e^{i\pi} = \cos \pi + i \sin \pi = -1 + 0 = -1,$$

known as Euler's Identity. This formula is considered remarkable, for it connects five central numbers in mathematics. It is also remarkable because it shows that e , an irrational, transcendental number, raised to an imaginary power equals -1 , a rational integer!

From De Moivre's Theorem, we can show that i^i has an infinite number of values. If we set $\theta = \frac{\pi}{2}$, then from Euler's formula, we have

$$e^{\frac{\pi i}{2}} = e^{i\left(\frac{\pi}{2}\right)} = \cos \frac{\pi}{2} + i \sin \frac{\pi}{2} = 0 + i = i.$$

Now, it follows that

$$i^i = \left(e^{\frac{\pi i}{2}}\right)^i = e^{-\frac{\pi}{2}} \approx -0.207879576.$$

This is another astonishing result. An imaginary number raised to an imaginary number is real!

Since $\frac{\pi}{2}$ is in radian measure, adding or subtracting multiples of 2π to the angle is valid. This means that $\frac{\pi}{2}$, $\frac{5\pi}{2}$, and $\frac{9\pi}{2}$ should all give the same value. Using $\theta = \frac{5\pi}{2}$ in De Moivre's Theorem, we have

$$e^{i\left(\frac{5\pi}{2}\right)} = \cos \frac{5\pi}{2} + i \sin \frac{5\pi}{2} = 0 + i = i.$$

So we are now certain that $e^{\frac{5\pi i}{2}}$ equals i as well. If we use $e^{\frac{5\pi i}{2}}$ to evaluate i^i , we find

$$i^i = \left(e^{\frac{5\pi i}{2}}\right)^i = e^{-\frac{5\pi}{2}} \approx 0.000388203.$$

Likewise, we try $\theta = -\frac{3\pi}{2}$, and obtain

$$e^{i\left(-\frac{3\pi}{2}\right)} = \cos \left(-\frac{3\pi}{2}\right) + i \sin \left(-\frac{3\pi}{2}\right) = 0 + i = i.$$

Therefore,

$$i^i = \left(e^{-\frac{3\pi i}{2}}\right)^i = e^{\frac{3\pi}{2}} \approx 111.31777.$$

If we try other values for i , such as $\frac{9\pi i}{2}$, $\frac{13\pi i}{2}$, $\frac{17\pi i}{2}$, and calculate i^i , we would get a new value each time, thus proving that there are an infinite number of values for i^i .

In 1739, De Moivre used his formula to find the n th complex roots of unity, i.e., the complex solutions of the equation $z^n = 1$, which gave coordinates in the complex plane for the vertices of a regular polygon with n sides and unit radius. There are n different n th roots of unity.

If $z = \cos \theta + i \sin \theta$, then

$$\begin{aligned} z^{\frac{1}{n}} &= (\cos \theta + i \sin \theta)^{\frac{1}{n}} \\ &= \cos \left(\frac{\theta + 2k\pi}{n} \right) + i \sin \left(\frac{\theta + 2k\pi}{n} \right), \text{ for } k = 0, 1, 2, \dots, n-1. \end{aligned}$$

There is only one first root of unity: $z = 1 = \cos 0 + i \sin 0$. If $n = 2$, then $z^2 = 1$, and so the square roots are ± 1 . If $n = 3$, then $z^3 = 1$, so that the three roots z_k , for $k = 0, 1, 2$, are:

$$\begin{aligned} z_0 &= \cos 0 + i \sin 0 = 1, \\ z_1 &= \cos \frac{2\pi}{3} + i \sin \frac{2\pi}{3} = \frac{-1 + i\sqrt{3}}{2}, \\ z_2 &= \cos \frac{4\pi}{3} + i \sin \frac{4\pi}{3} = \frac{-1 - i\sqrt{3}}{2}. \end{aligned}$$

Thus, the three cube roots of unity are: 1 , $\frac{-1+i\sqrt{3}}{2}$, and $\frac{-1-i\sqrt{3}}{2}$. Now, if $n = 4$, then

$$\begin{aligned} z_0 &= \cos 0 + i \sin 0 = 1, \\ z_1 &= \cos \frac{\pi}{2} + i \sin \frac{\pi}{2} = i, \\ z_2 &= \cos \pi + i \sin \pi = -1, \\ z_3 &= \cos \frac{3\pi}{2} + i \sin \frac{3\pi}{2} = -i. \end{aligned}$$

So, the 4 fourth roots of unity are: ± 1 and $\pm i$. De Moivre's method to find the n th roots of unity is much easier than trying to factor, because not all equations of $z^n - 1 = 0$ can be easily factored.

De Moivre's Theorem can easily be generalized to finding the n th roots of any complex number c , i.e., $z^n = c$. If $z = x + iy$ is a real number, then the complex roots must occur in conjugate pairs. Furthermore, by the Fundamental Theorem of Algebra, if $P(z)$ is a polynomial of degree n ($n > 0$), then the equation $P(z) = 0$ has precisely n distinct complex solutions. Geometrically, the n th roots of unity are equally spaced points that lie on the unit circle. And, if we connect these points on the unit circle, they will form a regular polygon with n sides. In the case where $n = 4$, we have a square.

Finally, consider the following Maclaurin power series representations:

$$\begin{aligned} \sin x &= x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots \\ \cos x &= 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \dots \end{aligned}$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} + \frac{x^6}{6!} + \frac{x^7}{7!} + \dots$$

These series converge absolutely for all x by the Ratio Test. Substituting ix for x in the Maclaurin representation for e^x , and recalling that $i^2 = -1$, we get:

$$\begin{aligned} e^{ix} &= 1 + ix + \frac{(ix)^2}{2!} + \frac{(ix)^3}{3!} + \frac{(ix)^4}{4!} + \frac{(ix)^5}{5!} + \frac{(ix)^6}{6!} + \frac{(ix)^7}{7!} + \dots \\ &= 1 + ix - \frac{x^2}{2!} - \frac{ix^3}{3!} + \frac{x^4}{4!} + \frac{ix^5}{5!} - \frac{x^6}{6!} - \frac{ix^7}{7!} + \dots \\ &= \left(1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \dots\right) + \left(ix - \frac{ix^3}{3!} + \frac{ix^5}{5!} - \frac{ix^7}{7!} + \dots\right) \\ &= \left(1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \dots\right) + i \left(x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots\right) \\ &= \cos x + i \sin x, \end{aligned}$$

thus giving Euler's formula.

3. Conclusion

The complex numbers were once very revolutionary, but now they are accepted as essential tools for mathematics as well as science and technology. The innovators and discoverers did not come upon their ideas by sticking to the accepted rules, but by letting their mind question ideas which others took for granted. It is a very fortunate thing that mathematicians invariably explore the "unaccepted" or "unreasonable" or else, perhaps, we might not have known of complex numbers.

It took time for scientists to accept the complex number system since they could not be shown as physical and real. However, now complex numbers have numerous applications. They are used to describe electric circuits and electromagnetic waves in engineering and physics (using the symbol j for -1 , rather than i). Complex numbers are essential in explaining the quantum theory of the atom, and complex numbers can be used to explain Kepler's laws and satellite orbits, and in the design and construction of aircraft.

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Baseball Statistics and Season Winning Percentage

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1. Introduction

When Bill James first started using mathematical formulas to evaluate baseball players and teams, many people discredited him. However, after being hired by the Boston Red Sox in 2002, Bill James played a major front-office role in the Red Sox winning their first World Series in 86 years, and along with the World Series title came an increased interest in sabermetrics. Sabermetrics is the “ultimate mathematical and statistical analysis of baseball player performance” [2]. The increased success of the use of sabermetrics in baseball decisions, such as with the 2004 Boston Red Sox, has led to numerous articles, books, and movies being made about the use of statistics in baseball.

Predictably, the increase in fascination about sabermetrics has led to more and more statistics being available to baseball fans, which can make it difficult to decipher which statistics are important. It can also be very difficult to compare the importance of statistics in different categories, namely between pitching and hitting statistics. As wins are the most important aspect of baseball, one must look at what statistics correlate the most to winning percentage to determine which ones are the most important, which is what this paper sets out to do.

This paper explains the process and results of a stepwise regression analysis, using three seasons worth of baseball statistics. Through analyzing some of the most common baseball statistics available to the common fan, a model is presented that helps predict season winning percentage.

2. Method

Statistics for all thirty Major League Baseball (MLB) teams from the 2009, 2010, and 2011 regular seasons were entered into SPSS statistics software. The statistics were obtained from ESPN's website, and all of them are team season summary statistics. These statistics were chosen because of their perceived popularity amongst baseball fans and analysts. Below is a list of the statistics (grouped by category) utilized in this research:

Offensive:

AVG = batting average (hits/official at-bats)

HR = home runs hit

OBP = on-base percentage

(total times reached base/plate appearances)

SLG = slugging percentage

$[(1*1B + 2*2B + 3*3B + 4*HR)/\text{official at-bats}]^\dagger$

RBI = runs batted in

(runs scored not as the result of a defensive error)

RUNS = runs scored

Pitching:

ERA = earned run average

(runs scored per nine innings not the result of an error)

OBA = opponent batting average

WHIP = walks, hits allowed per inning pitched

HA = total hits allowed

Other:

WIN = winning percentage

[†]Note: In the definition of slugging percentage, 1B refers to a single, 2B refers to a double, and 3B refers to a triple.

3. Correlation

When performing a linear regression analysis, correlation measures how close a scatter plot is to a line. Independent variables (in this case, independent variables are AVG, WHIP, RUNS, etc.) are correlated with the dependent variable (WIN). For a Pearson correlation (r) value, the closer the number is to 1 (directly correlated) or -1 (indirectly correlated), the more linear the data is. The coefficient of determination (r^2) determines what portion of the variation in the dependent variable is due to the in-

dependent variable [3, pp. 96-97]. Because of the large number of data points, SPSS was used in this research to calculate the correlation and r^2 values. Table 1 shows the results from SPSS for r and r^2 values.

	r	r^2
AVG	0.396	0.157
OBP	0.517	0.268
SLG	0.555	0.307
RBI	0.625	0.390
ERA	-0.605	0.366
OBA	-0.599	0.358
HA	-0.558	0.311
WHIP	-0.653	0.427
RUNS	0.634	0.402
HR	0.528	0.278

Table 1

WHIP, RUNS, RBI, and ERA are the four highest r^2 values, and thus individually, they each account for the most variation in winning percentage. Specifically, WHIP alone accounts for 42.7% of the variation in winning percentage. Furthermore, it is interesting to note that the r^2 value for AVG (batting average, offensive) is 0.157, whereas the r^2 value for OBA (opponent batting average, pitching) is 0.358. Therefore, opponent batting average accounts for over twice the percent variation in wins than does batting average. This gives credence to the idea that it is more important to prevent hits (strong pitchers) than get hits (strong offensive players). These correlation statistics alone do not provide enough data to definitively state that pitching and defense are more important than hitting, but they indicate that it is a strong possibility.

Because many of the variables used are highly correlated to one another (such as RUNS and RBI, which both count number of runs scored with a minor variation for RBI), the sum of the correlations of all of the statistics adds to more than 1 (100%). Since correlation is bounded by -1 and 1 , overlap occurs between the variables. This overlap amongst variables occurs because some of the variables account for the same variation in winning percentage as do other variables. It is difficult to find a combination of variables that explains the most variation in winning percentage because of the overlap that occurs. In order to take into account variables that account for similar variation in winning percentage, a stepwise regression analysis can be performed to better build a model to explain the variation in winning percentage.

4. Stepwise Regression

Stepwise regression is a linear regression analysis that includes/excludes variables based on a statistical rule, often determined by the computer program that is being used (such as SPSS). Stepwise regression combines forward and backward regression analysis; that is, variables can be added or deleted from the model. In stepwise regression, no variables are in the model to begin with, and variables are added based on how much they raise the combined r^2 value. Variables can also be removed from the model if they are no longer deemed significant by the statistical rule; however, in this particular stepwise regression analysis, no variables were ever deleted from the model. It is imperative to remember that stepwise regression focuses on a change in r^2 value. Variables are included/excluded because they cause the greatest increase in explained variance [3, p. 430]. Below are the steps for performing stepwise regression. (Note that, for this research, SPSS was used to complete the stepwise regression analysis.)

1. Find the r^2 value for all independent variables in relation to the dependent variable. Add the highest r^2 value to the model. This is the original one-variable model. Denote the independent variables by $X_1, X_2, X_3, \dots, X_n$ and the dependent variable by Y . Call the first variable added to the model X_1 .
2. Use a multivariate analysis to predict Y using X_1 and X_2 , use a multivariate analysis to predict Y using X_1 and X_3 (and then X_1 and X_4, X_1 and X_5 , etc.). By completing this step, one can take into account the correlation between variables and eliminate the overlap that occurs when using just r^2 values.
3. Calculate the r^2 value for each multivariate analysis. The two-variable model with the highest r^2 value replaces the original one-variable model. Denote the second variable added to the model by X_2 .
4. Use a multivariate analysis to predict Y using X_1, X_2 and $X_3; X_1, X_2$, and $X_4; \dots; X_1, X_2$ and X_n . Calculate r^2 values. Replace the two-variable model by the three-variable model with the highest r^2 value.
5. Repeat process until no new model raises the r^2 value by more than 1%.

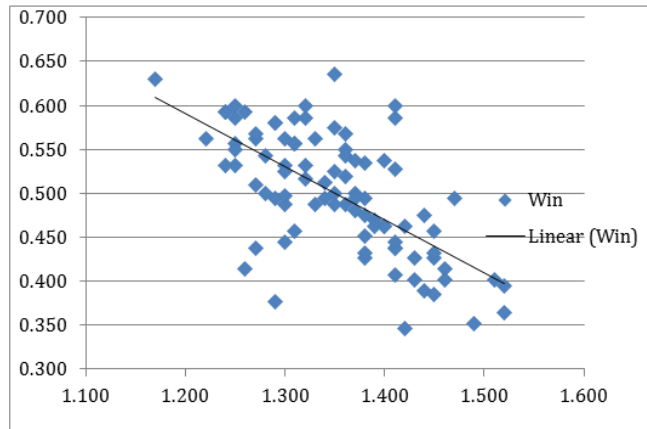


Figure 1: $WIN = 1.317 - 0.604(WHIP)$

The following outlines the steps for how stepwise regression was used in this research.

1. WHIP added to the model ($r^2 = 0.427$). Figure 1 shows the model that is created by using WHIP to predict WIN.
2. Use a multivariate analysis to predict WIN using WHIP and AVG, WHIP and OBP, WHIP and ERA, etc.
3. The two-variable model with the highest r^2 value includes WHIP and RUNS. This becomes the new model. The r^2 value for the new model is 0.837. This means that 83.7% of the variation in WIN is due to WHIP and RUNS.
4. The three-variable model with the highest r^2 value includes WHIP, RUNS, and ERA.
5. No four-variable models raised the r^2 value by more than 1%; thus, the stepwise regression analysis is discontinued and the third model is the final one.

5. Stepwise Regression Models

The models generated by SPSS using a stepwise regression are summarized in Table 2. According to this table, the third model accounts for 87.4% of the variance in wins.

	Correlation	r^2	Variables Included in Model
Model 1	.653	.427	WHIP
Model 2	.915	.837	WHIP, RUNS
Model 3	.935	.874	WHIP, RUNS, ERA

Table 2

6. Regression Equation

The regression equation for the third model is given in Figure 2. Using this regression equation, the following conclusions can be made. First, for each point decrease in WHIP, a team can expect to win 1.5% more games, which translates to 2.4 games over a 162-game season. Furthermore, for each point rise in runs scored per game, a team can expect to win 6.64% more games or 10.4 games in a 162-game season. Last, for each point decrease in ERA, a team can expect to win 8.88% more games or 14.3 games in a season. While this model may seem counterintuitive because WHIP was added to the model first but one point differential in WHIP does not account for as many additional wins as do RUNS or ERA, one must remember that the variables are not measuring exactly the same thing. For instance, WHIP measures walks and hits while ERA measures runs allowed. This difference in what variables measure accounts for the seemingly counterintuitive regression equation.

Probability of winning = $0.498 - 0.015(\text{WHIP}) + 0.0664(\text{RUNS}) - 0.088(\text{ERA})$
--

Figure 2: Regression Equation, Third Model

Just as Table 1 also indicated, this regression model indicates that it is more important to keep opposing teams from scoring runs than actually scoring runs. While much more research needs to be done in order to definitively state that pitching is more important to season winning percentage than hitting, this model provides more evidence in favor of this idea.

7. Conclusion

According to this stepwise regression model, WHIP, RUNS, and ERA are the statistics that correlate the most to season winning percentage. What is the most surprising, perhaps, about this model is the exclusion of some variables. For instance, a player wins baseball's offensive "Triple Crown" when he leads his league in batting average, home runs, and RBI's. While the Triple Crown is based on individual statistics and not team statistics as this research is, it is interesting to note that none of the three Triple Crown categories were included in the model.

8. Further Research

Further research opportunities on this topic are abundant. First, one could use statistics from individual games instead of season statistics. By doing this, a model could be created to predict the probability of winning an individual game. Also, the use of individual game statistics instead of team summary statistics could help evaluate specific players and their value to a team. By looking at individual statistics, it would also be possible to create a player evaluation formula to compare players. Furthermore, the same correlation tests and regression tests could be run for playoff statistics to see if the same variables that account for regular season winning percentage variation account for variation in playoff winning percentage.

9. Acknowledgements

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Kappa Mu Epsilon Quiz

Test your knowledge about Kappa Mu Epsilon! This quiz was distributed on April 12, 2013 at the National Convention held at Washburn University, and now you can try it. The answers are listed on page 20. Have fun!

1. Name the states with active Kappa, Mu, and Epsilon chapters of KME.
2. Which chapter matches its swampy and marshy geographical location?
3. Which state had the first Delta chapter?
4. Which state has held the record for having the most chapters active for the longest period of time?
5. Which state with five or more chapters has gone the longest without an installation of a new chapter?
6. Name the first letter of the Greek alphabet for which more active chapters of KME are named than are named for the preceding letter.
7. What is the greatest number of currently active chapters that happened to be installed in the same year, and what is the year?
8. Seventy years ago, was "University" or "Teacher's College" more commonly in the name of an institution with a KME chapter?
9. What chapter is credited with writing "The Math Student Blues," a song which appeared in *The Pentagon* some time in the 1940's?
10. Name the only active chapter of KME whose institution's name does not include either "University" or "College."
11. Name the only city with three active chapters of KME.
12. Which chapter has initiated the most total members into KME?
13. Which active chapter is located the furthest north?
14. Which active chapter is located the furthest east?

15. Name the only chapter not within the contiguous United States? And we would all love to attend a national convention there!
16. Which chapter is closest to bisecting the arc from the equator to the North Pole?
17. How many active chapters are in fully convex states?
18. Which chapter has within its university name, the name of the city nearby with a very successful professional sports team with three hypocycloids ($k = 4$, or astroids) in their team logo?
19. Which chapter is located in the same city as “Uncle Henry’s Farm”?
20. Which named chapter is furthest south in the continental United States?
21. What is the square root of the number of states that have had or still have a Kappa Mu Epsilon chapter?
22. What is our youngest chapter?
23. What was the last chapter installed before people walked on the moon?

Winning Entries

Each winning chapter receives \$50!

MO Beta: Amy Billups, Janine Decker, Tifini Gast,
and Alexandra Wolf (18/23 correct)

TX Alpha: Saba Nafees (14/23 correct)

Answers to the Kappa Mu Epsilon Quiz

Below are the answers to the questions that are on the previous pages.

1. Missouri and Pennsylvania
2. LA Delta
3. Illinois
4. Pennsylvania
5. Ohio
6. Eta
7. Six, in 1965, 1998, and 2005
8. Teacher's College
9. NY Alpha
10. CO Beta
11. Springfield, MO
12. NM Alpha
13. SD Alpha
14. MA Alpha
15. HI Alpha
16. WI Beta
17. 3, all in Colorado
18. PA Omicron
19. KS Delta
20. TX Nu
21. 6
22. RI Beta
23. PA Theta

The Problem Corner

Edited by Pat Costello

The Problem Corner invites questions of interest to undergraduate students. As a rule, the solution should not demand any tools beyond calculus and linear algebra. 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 new problems should be submitted on separate sheets before February 1, 2014. Solutions received after this will be considered up to the time when copy is prepared for publication. The solutions received will be published in the Spring 2014 issue of *The Pentagon*. Preference will be given to correct student solutions. Affirmation of student status and school should be included with solutions. New problems and solutions to problems in this issue should be sent to Pat Costello, Department of Mathematics and Statistics, Eastern Kentucky University, 521 Lancaster Avenue, Richmond, KY 40475-3102 (e-mail: pat.costello@eku.edu, fax: (859) 622-3051).

NEW PROBLEMS 722-729

Problem 722. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

Characterize those positive integers n for which $2^{n^2} + 1$ may be a prime number.

Problem 723. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

Prove that there are infinitely many primitive Pythagorean triples (a, b, c) , like $(5, 12, 13)$, with hypotenuse c such that the odd leg is a pentagonal number and the even leg is consecutive with the hypotenuse.

Problem 724. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

Let $T_n = \frac{n(n+1)}{2}$ be the n th triangular number. Prove that the fraction

$$\frac{T_2 T_4 T_6 \cdots T_{2n}}{T_1 T_3 T_5 \cdots T_{2n-1}}$$

is always an integer.

Problem 725. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

It is known that each integer $n > 11$ is the sum of two composite numbers but the usual proof of this uses two different expressions, one for n even and one for n odd. If we restrict our attention to certain sequences of the natural numbers, then we can find one expression for each of the numbers in the sequence as a sum of two composite numbers, regardless of parity. Do this for the squares greater than 9 and the triangular numbers greater than 10.

Problem 726. *Proposed by Jose Luis Diaz-Barrero, BARCELONA TECH, Barcelona, Spain.*

Let x , y , and z be positive real numbers. Prove that

$$\left(\frac{1}{x} + \frac{1}{y} + \frac{1}{z}\right) \left(\frac{xy}{y+z} + \frac{yz}{z+x} + \frac{zx}{x+y}\right) \geq \frac{9}{2}.$$

Problem 727. *Proposed by Jose Luis Diaz-Barrero, BARCELONA TECH, Barcelona, Spain.*

Let α , β , γ be the measure of the angles of a triangle ABC . Prove that

$$\sum_{cyclic} \frac{\sin \alpha}{4 \sin \beta + 5\sqrt{\sin \alpha \sin \beta}} \geq \frac{1}{3}.$$

Problem 728. *Proposed by Ovidiu Furdui, Technical University of Cluj-Napoca, Cluj, Romania.*

Calculate the integral

$$\int_0^1 (-1)^{\lfloor \frac{1}{x} \rfloor} dx.$$

Problem 729. *Proposed by the editor.*

Find the number of distinct 5-letter strings that can be made from the letters in the word TENNESSEE. The two strings EENNE and ENENE are among the strings to count.

SOLUTIONS TO PROBLEMS 699-709

Problem 699. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

1. Find all positive integers x such that $2^x + 2^{11} + 2^8$ is a perfect square.
2. Find all positive integers x such that $4^x + 4^{11} + 4^8$ is a perfect square.

Solution *by the Ashland University Problem Solving Group, Ashland University, Ashland, Ohio.*

For each part of the problem, either $x < 8$ or $x \geq 8$.

1. We check $x < 8$ first:

$$\begin{aligned} 2^1 + 2^{11} + 2^8 &= 2306, & 2^2 + 2^{11} + 2^8 &= 2308, \\ 2^3 + 2^{11} + 2^8 &= 2312, & 2^4 + 2^{11} + 2^8 &= 2320, \\ 2^5 + 2^{11} + 2^8 &= 2336, & 2^6 + 2^{11} + 2^8 &= 2368, \\ 2^7 + 2^{11} + 2^8 &= 2432, \end{aligned}$$

and none of these are perfect squares.

If $x \geq 8$, we can factor out 2^8 from each term and get

$$2^x + 2^{11} + 2^8 = 2^8 (2^{x-8} + 2^3 + 1) = a^2,$$

where a^2 is the unknown square. Since 2^8 is a square, $2^{x-8} + 2^3 + 1$ must be a square. So, $2^{x-8} + 9 = b^2$ for some positive integer b . Now,

$$2^{x-8} + 9 = b^2 \iff 2^{x-8} = b^2 - 9 = (b-3)(b+3).$$

Since the left-hand side is divisible by 2, 2 must also divide the right-hand side. So $b-3 = 1$ or $2|(b-3)$. If $b-3 = 1$, then $b = 4$ and $2^{x-8} = 7$ which is impossible. So $2|(b-3)$. Since it is a power of 2 on the left-hand side, we also have $2|(b+3)$. Now, $b-3 = 2^k$ and $b+3 = 2^l$ for some integers k and l . This means $6 = 2^l - 2^k$ and $l = 3$ and $k = 1$. Hence, $2^{x-8} = 2^4$ which says $x = 12$ is the only solution.

2. We check $x < 8$ first:

$$\begin{aligned} 4^1 + 4^{11} + 4^8 &= 4259844, & 4^2 + 4^{11} + 4^8 &= 4259856, \\ 4^3 + 4^{11} + 4^8 &= 4259904, & 4^4 + 4^{11} + 4^8 &= 4260096 = 2064^2, \\ 4^5 + 4^{11} + 4^8 &= 4260864, & 4^6 + 4^{11} + 4^8 &= 4263936, \\ 4^7 + 4^{11} + 4^8 &= 4276224. \end{aligned}$$

The only one of these that is a perfect square is when $x = 4$.

If $x \geq 8$, we can factor out 4^8 from each term and get

$$4^x + 4^{11} + 4^8 = 4^8 (4^{x-8} + 4^3 + 1) = a^2,$$

where a^2 is the unknown square. Since 4^8 is a square, $4^{x-8} + 4^3 + 1$ must be a square. So, $4^{x-8} + 65 = b^2$ for some positive integer b .

$$\begin{aligned} 4^{x-8} + 65 = b^2 &\iff (2^{x-8})^2 + 65 = b^2 \\ &\iff b^2 - (2^{x-8})^2 = 65 \\ &\iff (b - 2^{x-8})(b + 2^{x-8}) = 65. \end{aligned}$$

There are only two ways to write 65 as a product of two positive integers: $65 * 1$ and $13 * 5$. If $b + 2^{x-8} = 65$ and $b - 2^{x-8} = 1$, then $b = 33$ and $2^{x-8} = 32$, so $x = 13$. If $b + 2^{x-8} = 13$ and $b - 2^{x-8} = 5$, then $b = 9$ and $2^{x-8} = 4$, so $x = 10$. Hence, the only solutions are $x = 4, 10, 13$.

Also solved by Yu-Hsuan (Stanley) Ho, University of Central Missouri, Warrensburg, MO; Oklahoma Alpha Chapter, Northeastern State University, Tahlequa, OK; Paul Bruckman, Nanaimo, BC (Canada); Drake Math Club, Drake University, Des Moines, IA; Titu Zvonaru, Comanesti, Romania and Neculai Stanciu, George Emil Palade School, Buzau, Romania; and the proposer. Ioan Viorel Codreanu, Satulung, Maramures, Romania and Frank Battles, Plymouth, MA both solved part 1. and found one solution for part 2.

Problem 700. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

The prime 19, when rotated 180 degrees yields the prime number 61. It is also true that the pairs 199 and 661, as well as 1999 and 6661, are prime numbers. The next occurrence of such prime pairs is $1999 \dots 9$ and $6666 \dots 61$, where the number of digits is 28. Prove that there are infinitely many occurrences where both $1999 \dots 9$ and $6666 \dots 61$ are simultaneously composite.

Solution *by the proposer.*

Let the pair of numbers be denoted a and b with a being the smaller value. Suppose there are n copies of the digit 9 in the decimal form of a . Then,

$$a = 2(10^n) - 1$$

and

$$b = 60 \left(\frac{10^n - 1}{9} \right) + 1 = 20 \left(\frac{10^n - 1}{3} \right) + 1.$$

We will work on both expressions modulo 7. The claim is that both a and b are multiples of 7 for the special choice of exponent $n = 4 + 6k$, where $k = 0, 1, 2, \dots$. We have, modulo 7,

$$a \equiv 2 \left(3^{4+6k} \right) - 1 \equiv 2(81)(3^6)^k - 1 \equiv 2(4)(1^k) - 1 \equiv 0,$$

so 7 divides a . Likewise,

$$\begin{aligned} b &= 20 \left(\frac{10^n - 1}{3} \right) + 1 = 10 \left(\frac{2 * 10^n - 2}{3} \right) + 1 \\ &= 10 \left(\frac{2 * 10^n - 1 - 1}{3} \right) + 1 \\ &\equiv 3 \left(\frac{(2 * 10^n - 1) - 1}{3} \right) + 1 \\ &\equiv 3 \left(\frac{a - 1}{3} \right) + 1 \equiv a \equiv 0, \end{aligned}$$

so 7 divides b .

Also solved by Drake Math Club, Drake University, Des Moines, IA; Frank Battles, Plymouth, MA; and Paul Bruckman, Nanaimo, BC (Canada).

Problem 701. *Proposed by Tom Moore, Bridgewater State University, Bridgewater, MA.*

Let φ be the Euler φ -function (so $\varphi(m)$ is the number of values less than m which are relatively prime to m). The congruence $a^m \equiv a \pmod{\varphi(m)}$ is true for all a relatively prime to $\varphi(m)$ when $m = 3, 4, 5$, and 6 . Show that this congruence fails for infinitely many m .

Solution *by the proposer.*

We claim that it fails for $m = 2^k$ with $k \geq 3$ and $a = 3$. If $3^{2^k} \equiv 3 \pmod{\varphi(2^k)}$, this means $3^{2^k} \equiv 3 \pmod{2^{k-1}}$. But, Euler's theorem says that $a^{\varphi(m)} \equiv 1 \pmod{m}$ for all a relatively prime to m . So, $3^{2^{k-1}} \equiv 1 \pmod{2^k}$. Squaring, we get $3^{2^k} \equiv 1 \pmod{2^k}$. Interpreting these congruences as division statements, we have $2^{k-1} | (3^{2^k} - 3)$ and $2^k | (3^{2^{k-1}} - 1)$. Therefore, $3^{2^k} - 3 = 2^{k-1}s$ and $3^{2^{k-1}} - 1 = 2^k t$, for some integers s and t . Substituting the latter into the former gives $2^k t - 2 = 2^{k-1}s$, and dividing by 2 gives $2^{k-1}t - 1 = 2^{k-2}s$. But, when $k \geq 3$, this says an odd integer equals an even integer which is a contradiction. Hence, the congruence fails in these cases.

Also solved by Paul Bruckman, Nanaimo, BC (Canada).

Problem 702. Proposed by Pedro H.O. Pantoja (student), University of Natal, Brazil.

Let $\pi(n)$ be the number of primes less than or equal to n . Prove that the sum

$$\sum_{n=2}^{\infty} \frac{1}{n(\pi(n))^{1+\varepsilon}}$$

converges for all $\varepsilon > 0$.

Solution by the proposer.

We use Bertrand's Postulate (that between n and $2n$ there is a prime) to note that $\pi(2^k) > k$ for every natural number $k > 1$. Choose $n > 2$ such that $e^{n-1} < x < e^n$. Then, $\log x \leq n \log e = n$. Additionally, choose $n > 3.26$ and you will have $e^{n-1} > 2^n$. Since the function $\pi(x)$ is nondecreasing, we have $\pi(x) > \pi(e^{n-1}) > \pi(2^n) > n \geq \log x$ which says $\pi(x) \geq \log x$. Then, $n(\pi(n))^{1+\varepsilon} \geq n(\log n)^{1+\varepsilon}$. The improper integral

$$\int_2^{\infty} \frac{dx}{x(\log x)^{1+\varepsilon}}$$

converges to $\frac{1}{\varepsilon(\log 2)^\varepsilon}$. Hence, the integral test says that

$$\sum_{n=2}^{\infty} \frac{1}{n(\log n)^{1+\varepsilon}}$$

converges. Finally, since $n(\pi(n))^{1+\varepsilon} \geq n(\log n)^{1+\varepsilon}$, the comparison test says that

$$\sum_{n=2}^{\infty} \frac{1}{n(\pi(n))^{1+\varepsilon}}$$

converges.

Also solved by Paul Bruckman, Nanaimo, BC (Canada).

Problem 703. Proposed by Pedro H.O. Pantoja (student), University of Natal, Brazil.

Let x , y , and z be positive real numbers. Prove that

$$\begin{aligned} & (x^3 + y^3 + z^3 + 3xyz)^{2(x+y+z)} \\ & \geq [2xy(x+y+z)]^{x+y} \cdot [2yz(x+y+z)]^{y+z} \cdot [2xz(x+y+z)]^{x+z}. \end{aligned}$$

Solution by the proposer.

Suppose without loss of generality that $x \geq y \geq z$. Then,

$$x(x-y)(x-z) + y(y-x)(y-z) + z(z-x)(z-y) \geq 0$$

which implies

$$x^3 - x^2z - x^2y + xyz + y^3 - y^2z - y^2x + xyz + z^3 - z^2y - z^2x + xyz \geq 0$$

and

$$\begin{aligned} x^3 + y^3 + z^3 + 3xyz &\geq x^2z + x^2y + y^2z + y^2x + z^2y + z^2x \\ &= xy(x+y) + yz(y+z) + zx(z+x). \end{aligned}$$

Dividing both sides by $2(x+y+z)$ gives

$$\begin{aligned} \frac{x^3 + y^3 + z^3 + 3xyz}{2(x+y+z)} &\geq \frac{xy(x+y) + yz(y+z) + zx(z+x)}{2(x+y+z)} \\ &\geq ((xy)^{x+y}(yz)^{y+z}(zx)^{z+x})^{\frac{1}{2(x+y+z)}} \end{aligned}$$

by the AM-GM Inequality. So,

$$\left(\frac{x^3 + y^3 + z^3 + 3xyz}{2(x+y+z)} \right)^{2(x+y+z)} \geq (xy)^{x+y}(yz)^{y+z}(zx)^{z+x},$$

and clearing the denominator,

$$\begin{aligned} (x^3 + y^3 + z^3 + 3xyz)^{2(x+y+z)} &\geq [2(x+y+z)]^{2(x+y+z)}(xy)^{x+y}(yz)^{y+z}(zx)^{z+x} \\ &= [2xy(x+y+z)]^{x+y}[2yz(x+y+z)]^{y+z}[2zx(x+y+z)]^{z+x}. \end{aligned}$$

Also solved by Ioan Viorel Codreanu, Satulung, Maramures, Romania; and Paul Bruckman, Nanaimo, BC (Canada).

Problem 704. Proposed by D.M. Batinetu-Giurgiu, Matei Basarab National College, Bucharest, Romania and Neculai Stanciu, George Emil Palade Secondary School, Buzau, Romania.

Let $\{a_n\}$ and $\{b_n\}$ be sequences of positive real numbers with

$$\lim_{n \rightarrow \infty} \frac{a_{n+1}}{n^2 a_n} = a \text{ and } \lim_{n \rightarrow \infty} \frac{b_{n+1}}{n^3 b_n} = b.$$

Find

$$\lim_{n \rightarrow \infty} \left(\sqrt[n+1]{\frac{b_{n+1}}{a_{n+1}}} - \sqrt[n]{\frac{b_n}{a_n}} \right).$$

Solution by the proposers.

We have

$$\begin{aligned} \lim_{n \rightarrow \infty} \frac{\sqrt[n]{a_n}}{n^2} &= \lim_{n \rightarrow \infty} \sqrt[n]{\frac{a_n}{n^{2n}}} \\ &= \lim_{n \rightarrow \infty} \frac{a_{n+1}}{(n+1)^{2n+2}} * \frac{n^{2n}}{a_n}, \text{ by Cauchy-D'Alembert} \\ &= \lim_{n \rightarrow \infty} \frac{a_{n+1}}{(n+1)^2 a_n} * \frac{1}{e_n^2}, \text{ where } e_n = \left(1 + \frac{1}{n}\right)^n \\ &= \frac{a}{e^2}. \end{aligned}$$

Similarly, we have

$$\lim_{n \rightarrow \infty} \frac{\sqrt[n]{b_n}}{n^3} = \frac{b}{e^3}.$$

Let

$$u_n = \sqrt[n+1]{\frac{b_{n+1}}{a_{n+1}}} * \sqrt[n]{\frac{a_n}{b_n}},$$

for all integers $n > 1$. We obtain that

$$\begin{aligned} \lim_{n \rightarrow \infty} u_n &= \lim_{n \rightarrow \infty} \frac{\sqrt[n+1]{b_{n+1}}}{(n+1)^3} * (n+1)^3 * \frac{(n+1)^2}{\sqrt[n+1]{a_{n+1}}} * \frac{1}{(n+1)^2} * \frac{\sqrt[n]{a_n}}{n^2} * n^2 * \frac{n^3}{\sqrt[n]{b_n}} * \frac{1}{n^3} \\ &= \frac{b}{e^3} * \frac{e^2}{a} * \frac{a}{e^2} * \frac{e^3}{b} * \lim_{n \rightarrow \infty} \frac{n+1}{n} = 1. \end{aligned}$$

Since this limit is 1,

$$\lim_{n \rightarrow \infty} \frac{u_n - 1}{\ln u_n} = 1.$$

Then, we have

$$\begin{aligned} \lim_{n \rightarrow \infty} u_n^n &= \lim_{n \rightarrow \infty} \frac{b_{n+1}}{n^3 b_n} * \frac{n^2 a_n}{a_{n+1}} * \frac{\sqrt[n+1]{a_{n+1}}}{(n+1)^2} * \frac{(n+1)^3}{\sqrt[n+1]{b_{n+1}}} \\ &= \frac{b}{a} * \frac{a}{e^2} * \frac{e^3}{b} = e. \end{aligned}$$

Hence,

$$\begin{aligned} \lim_{n \rightarrow \infty} \left(\sqrt[n+1]{\frac{b_{n+1}}{a_{n+1}}} - \sqrt[n]{\frac{b_n}{a_n}} \right) &= \lim_{n \rightarrow \infty} \sqrt[n]{\frac{b_n}{a_n}} (u_n - 1) \\ &= \lim_{n \rightarrow \infty} \frac{\sqrt[n]{b_n}}{n^3} * \frac{n^2}{\sqrt[n]{a_n}} * \frac{u_n - 1}{\ln u_n} * \ln u_n^n \end{aligned}$$

$$\begin{aligned}
&= \frac{b}{e^3} * \frac{e^2}{a} * 1 * \ln e \\
&= \frac{b}{a * e}.
\end{aligned}$$

Problem 705. *Proposed by Anastasios Kotronis, Athens, Greece.*

Let

$$a_n = \left(\sum_{k=0}^n \frac{n^k (n^k + 1)}{n^{2k} + 1} \right)^{\frac{1}{n(n+1)}}.$$

Find the following limits.

1. $\lim_{n \rightarrow \infty} a_n$
2. $\lim_{n \rightarrow \infty} \frac{n^2(a_n - 1)}{\ln n}$
3. $\lim_{n \rightarrow \infty} \frac{n^3(a_n - 1)}{\ln n} - n$

Solution by the proposer.

$$\begin{aligned}
a_n &= \exp \left(\frac{1}{n(n+1)} \ln \left(1 + \sum_{k=1}^n \frac{1 + n^{-k}}{1 + n^{-2k}} \right) \right) \\
&= \exp \left(\frac{1}{n(n+1)} \ln \left(1 + \sum_{k=1}^n (1 + n^{-k}) (1 + O(n^{-2k})) \right) \right) \\
&= \exp \left(\frac{1}{n(n+1)} \ln \left(1 + \sum_{k=1}^n (1 + n^{-k} + O(n^{-2k})) \right) \right) \\
&= \exp \left(\frac{1}{n(n+1)} \ln \left(1 + n + O \left(\sum_{k=1}^n n^{-2k} \right) \right) \right) \\
&= \exp \left(\frac{1}{n(n+1)} \ln (1 + n + O(n^{-1})) \right) \\
&= \exp \left(\frac{\ln n}{n(n+1)} + \frac{1}{n(n+1)} \ln \left(1 + \frac{1}{n} + O(n^{-2}) \right) \right) \\
&= \exp \left(\frac{\ln n}{n(n+1)} + O(n^{-3}) \right)
\end{aligned}$$

$$\begin{aligned}
&= \exp\left(\frac{\ln n}{n^2} - \frac{\ln n}{n^3} + O(n^{-3})\right) \\
&= 1 + \frac{\ln n}{n^2} - \frac{\ln n}{n^3} + O(n^{-3}).
\end{aligned}$$

And so we have

1. $\lim_{n \rightarrow \infty} a_n = 1$
2. $\lim_{n \rightarrow \infty} \frac{n^2(a_n-1)}{\ln n} = 1$
3. $\lim_{n \rightarrow \infty} \frac{n^3(a_n-1)}{\ln n} - n = -1$

[*Mathematica* will find these limits.]

Problem 706. *Proposed by Jose Luis Diaz-Barrero, Universitat Politecnica de Catalunya, Barcelona, Spain.*

Let x be a positive real number. Prove that

$$\frac{x + \{x\}}{[x]^2 + 2\{x\}^2} + \frac{x + [x]}{\{x\}^2 + 2[x]^2} < \frac{4}{x},$$

where $[x]$ and $\{x\}$ are the integer and fractional parts of x , respectively.

Solution by the proposer.

We have $x = [x] + \{x\}$. Letting $a = [x]$ and $b = \{x\}$, the given inequality can be written as

$$\frac{a + 2b}{a^2 + 2b^2} + \frac{b + 2a}{b^2 + 2a^2} < \frac{4}{a + b}.$$

Now, we claim that

$$\frac{(a + b)(a + 2b)}{a^2 + 2b^2} + \frac{(a + b)(b + 2a)}{b^2 + 2a^2} \leq 4.$$

Indeed,

$$\frac{(a + b)(a + 2b)}{a^2 + 2b^2} = 1 + \frac{3ab}{a^2 + 2b^2} = 1 + \frac{3ab}{(a^2 + b^2) + b^2} \leq 1 + \frac{3a}{2a + b},$$

since $2ab \leq a^2 + b^2$. Likewise, we get

$$\frac{(a + b)(b + 2a)}{b^2 + 2a^2} \leq 1 + \frac{3b}{a + 2b}.$$

Therefore,

$$\frac{(a+b)(a+2b)}{a^2+2b^2} + \frac{(a+b)(b+2a)}{b^2+2a^2} \leq 2 + 3 \left(\frac{a}{2a+b} + \frac{b}{a+2b} \right).$$

To see that the right side is ≤ 4 , it will suffice to prove that

$$3 \left(\frac{a}{2a+b} + \frac{b}{a+2b} \right) \leq 2 \iff 3(a^2 + 4ab + b^2) \leq 2(2a+b)(a+2b) \\ \iff 0 \leq (a-b)^2,$$

which is clearly true. The claimed inequality is strict because there does not exist any positive number x where $[x] = \{x\}$.

Also solved by Titu Zvonaru, Comanesti, Romania and Neculai Stanciu, George Palade School, Buzau, Romania; Paul Bruckman, Nanaimo, BC (Canada); and Ioan Viorel Codreanu, Satulung, Maramures, Romania.

Problem 707. *Proposed by Jose Luis Diaz-Barrero, Universitat Politecnica de Catalunya, Barcelona, Spain.*

Let n be an odd positive integer and p a prime number of the form $3n + 2$. Prove that if

$$\frac{a}{b} = \sum_{i=1}^{2n+1} \frac{(-1)^{i+1}}{i},$$

then p divides a .

Solution by Paul Bruckman, Nanaimo, BC (Canada).

Let

$$H_n = \sum_{k=1}^n \frac{1}{k} \quad \text{and} \quad S_n = \sum_{i=1}^{2n+1} \frac{(-1)^{i+1}}{i}.$$

Then,

$$S_n = \left(1 + \frac{1}{3} + \frac{1}{5} + \cdots + \frac{1}{2n+1} \right) - \frac{1}{2} \left(1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n} \right) \\ = H_{2n+1} - H_n.$$

We are told that $p = 3n + 2$ is prime. Therefore,

$$S_n = S_{\frac{p-2}{3}} = H_{\frac{2p-1}{3}} - H_{\frac{p-2}{3}} = \frac{a}{b}.$$

Since n is odd, we must have $p = 6m - 1$ for some $m \geq 1$. Then,

$$S_n = H_{4m-1} - H_{2m-1} = \frac{a}{b}.$$

We wish to prove that in this case, $a \equiv 0 \pmod{p}$. Let x be any integer in

the set $R_p = \{1, 2, 3, \dots, p-1\}$ and consider H_{p-x} . We note that

$$H_{p-x} \equiv 1^{-1} + 2^{-1} + \dots + (p-x)^{-1} \pmod{p},$$

and that all reciprocals are inverses modulo p which are well-defined elements of R_p . Also,

$$\begin{aligned} -H_{p-x} &\equiv (p-1)^{-1} + (p-2)^{-1} + (p-3)^{-1} + \dots + x^{-1} \\ &\equiv H_{p-1} - H_{x-1} \pmod{p}, \end{aligned}$$

where $H_0 = 0$ (if necessary). By a theorem due to Wolstenholme,

$$H_{p-1} \equiv 0 \pmod{p^2}.$$

We only need to know that $H_{p-1} \equiv 0 \pmod{p}$. We then have the corollary $H_{p-x} \equiv H_{x-1} \pmod{p}$, for all $x \in R_p$; if $x = 1$, we have the weaker version of Wolstenholme's Theorem. In particular, if $x = \frac{p+1}{3} = 2m$, we have

$$H_{\frac{2p-1}{3}} \equiv H_{\frac{p-2}{3}} \pmod{p}, \text{ i.e., } H_{4m-1} \equiv H_{2m-1} \pmod{p}.$$

It follows that if $S_n = \frac{a}{b}$, then $a \equiv 0 \pmod{p}$.

Also solved by Ioan Viorel Codreanu, Satulung, Maramures, Romania; and the proposer.

Problem 708. *Proposed by Mary Kay Schippers and Hongbiao Zeng, Fort Hays State University, Hays, KS.*

Let $\{P_n\}$ be a sequence defined as follows:

$$P_1 = \frac{1}{4}, P_2 = \frac{1}{8},$$

$$4P_n = 2P_{n-1} + P_{n-2}, n \geq 3.$$

Calculate the following values.

1. $\sum_{n=1}^{\infty} P_n$
2. $\sum_{n=1}^{\infty} nP_n$

Solution by Frank Battles, Plymouth, MA.

We note that

$$P_n = \frac{F_n}{2^{n+1}},$$

where F_n represents the n th Fibonacci number with

$$\begin{aligned} F_1 &= 1, F_2 = 1, \\ F_n &= F_{n-1} + F_{n-2}, n \geq 3. \end{aligned}$$

The recurrence can be readily solved using conventional methods (or by adapting Binet's Formula for the Fibonacci numbers) obtaining

$$P_n = \frac{1}{2\sqrt{5}} \left[\left(\frac{1 + \sqrt{5}}{4} \right)^n - \left(\frac{1 - \sqrt{5}}{4} \right)^n \right].$$

1. For a geometric series with $|x| < 1$, we have

$$\sum_{n=1}^{\infty} x^n = \frac{1}{1-x} - 1.$$

Applying this to the above, we get

$$\sum_{n=1}^{\infty} P_n = \frac{1}{2\sqrt{5}} \left[\left(\frac{1}{1 - \frac{1+\sqrt{5}}{4}} - 1 \right) - \left(\frac{1}{1 - \frac{1-\sqrt{5}}{4}} - 1 \right) \right] = 1.$$

2. For a series with $|x| < 1$, we have

$$\sum_{n=1}^{\infty} nx^n = \frac{x}{(1-x)^2}.$$

Applying this to the above, we get

$$\sum_{n=1}^{\infty} nP_n = \frac{1}{2\sqrt{5}} \left[\frac{\frac{1+\sqrt{5}}{4}}{\left(1 - \frac{1+\sqrt{5}}{4}\right)^2} - \frac{\frac{1-\sqrt{5}}{4}}{\left(1 - \frac{1-\sqrt{5}}{4}\right)^2} \right] = 5.$$

Also solved by Drake Math Club, Drake University, Des Moines, IA; Paul Bruckman, Nanaimo, BC (Canada); Juan Gabriel Alonso, Garoe Secondary School, Las Palmas de Gran Canaria, Spain and Angel Plaza, Universidad de Las Palmas de Gran Canaria, Spain; G. C. Greubel, Old Dominion University, Norfolk, VA; and the proposers.

Problem 709. *Proposed by Michael Woltermann, Washington and Jefferson College, Washington, PA.*

Prove the following identities:

1. $\cos a\theta \cos (a-1)\theta + \tan a\theta \sin a\theta \cos (a-1)\theta = \cos \theta + \sin \theta \tan a\theta$
2. $(2 \cos a\theta) \left(\cos (a-1)\theta - \frac{\sin(a-1)\theta}{\tan 2a\theta} \right) = \cos \theta + \frac{\sin \theta}{\tan a\theta}$,

and give geometric interpretations of them when $a > 1$ and $0 < \theta < \frac{\pi}{2a}$.

Solution by Paul Bruckman, Nanaimo, BC (Canada).

For brevity, we write c_k for $\cos k\theta$, s_k for $\sin k\theta$, and t_k for $\tan k\theta$.

1. We seek to prove:

$$c_a c_{a-1} + t_a s_a c_{a-1} = c_1 + s_1 t_a.$$

The left-hand side is

$$\frac{c_{a-1}}{c_a} (c_a^2 + s_a^2) = \frac{c_{a-1}}{c_a}.$$

The right-hand side is

$$\frac{1}{c_a} (c_1 c_a + s_1 s_a) = \frac{c_{a-1}}{c_a},$$

demonstrating that the equation is true.

2. We seek to prove:

$$2c_a \left(c_{a-1} - \frac{s_{a-1}}{t_{2a}} \right) = c_1 + \frac{s_1}{t_a}.$$

The left-hand side is

$$\frac{2c_a}{s_{2a}} (c_{a-1} s_{2a} - s_{a-1} c_{2a}) = \frac{2c_a}{2c_a s_a} (s_{a+1}) = \frac{s_{a+1}}{s_a}.$$

The right-hand side is

$$\frac{1}{s_a} (s_a c_1 + c_a s_1) = \frac{s_{a+1}}{s_a},$$

demonstrating that the equation is true.

If $a > 1$ and $0 < \theta < \frac{\pi}{2a}$, the answer to part 1. simplifies to a result that is in the interval $(0, \sin \frac{\pi}{2a})$; the answer to part 2. simplifies to a result that is in the possibly larger interval $(0, \cos \frac{\pi}{2a})$. The two intervals are identical for $a = 2$.

Also solved by the proposer.

Kappa Mu Epsilon News

Edited by Peter Skoner, Historian

Updated information as of April 2013

Send news of chapter activities and other noteworthy KME events to

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 or to
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Installation Report

Rhode Island Beta Chapter
 Bryant University

The installation of the Rhode Island Beta Chapter of Kappa Mu Epsilon was held in the Faculty Dining Room on the campus of Bryant University in Smithfield, RI on Wednesday, April 3, 2013. The evening began with dinner, followed by a mathematical talk by KME National President Ron Wasserstein. Then came the installation, which was conducted by Dr. Alan Olinsky and the installing officer was National President Ron Wasserstein. The following students were initiated as the charter members. (Those who were also installed as officers are noted below.)

Caitlin Allen	Huy Nhat Ho
Samantha Andrews	Jessica Nolan
Taylor Bell	Kyle Nyskohus
Delaney Carr (Recording Secretary)	Jeffrey Pierro
Marissa Cohen	Kerry Quirk
Elise Daniell	Ariana Ricci
Robert Davis	Sarah Segill
Andrew DiFronzo (Vice President)	Paul Sheard
Joan Graham	Stephanie Smyers
Olivia Jankins	Bryan Start
Amanda Jillson	Matthew Tomlinson
Michael Leonard	Alyssa Westfall
Corinne Loiacono	Lindsey Wilson
Summer Lyons (Treasurer)	James Wood (President)
Megan Mapp	

Dr. John Quinn was installed as the corresponding secretary and Dr. Alan Olinsky as the faculty sponsor.

The following faculty were initiated as charter members:

Billie Anderson	Kristin Kennedy	John Quinn
James Bishop	Robert Muksian	Michael Salzillo
Joseph Capalbo	Alan Olinsky	Phyllis Schumacher
Thomas Hartl	Chester Piascik	Richard Smith
Louise Hasenfus		

The Vice President for Academic Affairs, Dr. Jose-Marie Griffiths, and other guests also attended the proceedings.

Chapter News

AL Zeta – Birmingham-Southern College

Chapter President – Niño Yu Tiamco; 50 Current Members

Other Fall 2012 Officers: Melanie Short, Vice President; Huda Qureshi, Secretary; Courtney Mauck, Treasurer; Andrew Conner, Executive Council; and Maria Stadnik, Corresponding Secretary and Faculty Sponsor

KME and the Department of Mathematics at Birmingham-Southern College sponsored a special Colloquium on November 6, 2012. Professor Bruce Atkinson from Samford University in Birmingham, Alabama gave a talk entitled “Analytic extensions of functions of a real variable.” He discussed ways to extend well known functions analytically to the complex plane and then discussed ways to extend the factorial and double factorial functions analytically. He concluded with a brief discussion of the Gamma function and the Riemann Zeta function and how these are analytic extensions of certain real functions.

AL Theta – Jacksonville State University

Chapter President – Nicholas Charles; 50 Current Members; 22 New Members

Other Fall 2012 Officers: Noel Overton, Vice President; Allison Clark, Secretary; Brittney Kingery, Treasurer; and Dr. David Dempsey, Corresponding Secretary and Faculty Sponsor

The Alabama Theta Chapter is planning their annual Spring Initiation Ceremony for March 20, 2013. The officers are also working with the Faculty Sponsor to create a KME chapter Facebook group to encourage communication among members.

New Initiates - Jessica Leigh Arighi, Shannon Allene Bolton, Kristen Taylor Carlisle, John Carrasquillo, Lindsey Nicole Ennis, Kevin Fathi, Rachel Kali Gibbs, Katherine Marie Greenhill, Kaitlyn D. Ledbetter, Jonathan B. Leftwich, Misty M. Lewis, Melissa Jean Lorenz, Katlin Marie Maddox, Kathrynne G. Marsh, Jeremy W. Moses, Paitra Economou Onkst, Jonathan C. Roberts, Rebecca Romine, Jason R. Shuster, Amber Nicole Simpson, Olivia Ellis Smith, and Clint Adam Stanley.

AR Beta – Henderson State University

Corresponding Secretary – Dr. Fred Worth; 8 New Members

New Initiates - James Easterling, III, Alejandra Hernandez, Samantha Lemp, David Neal, Katie Roberts, Eric Torres, Bonifride Tuyishimire, and Erin Yancey.

CA Gamma – Cal Poly

Corresponding Secretary – Jonathan Shapiro; 9 New Members

New Initiates - Chad Duna, Max Garcia, Tanner Gibson, Dana Hipolite, Brian Jones, Caleb Miller, Allison Scheppelmann, John Shamshoian, and Andrew Wang.

CO Delta – Colorado Mesa University

Corresponding Secretary – Eric Packard; 8 New Members

New Initiates - Shane T. Daniels, Mandy L. Johnson, Tyler W. Nelson, Christina A. Reed, Shawn Robinson, Scott A. Toovey, Derek L. West, and Eric S. Wilcox.

GA Alpha – University of West Georgia

Corresponding Secretary – Scott Sykes; 5 New Members

New Initiates - Jillian Littlejohn, Joseph McCord, Manda L. Moon, Hilary Rimmer, and Karina Robinson.

GA Beta – Georgia College & State University

Corresponding Secretary – Rodica Cazacu; 3 New Members

New Initiates - Rujeko Chinomona, Sarah Huskisson, and Andrew Pangia.

HI Alpha – Hawai'i Pacific University

Chapter President – Matt Troglia; 10 Current Members; 5 New Members

Other Fall 2012 Officers: Isaac Kim, Vice President; Laura Mitchell, Secretary; and Tara Davis, Corresponding Secretary and Faculty Sponsor

This past semester we had a few activities including the initiation ceremony, as well as some events that were joint with our math club: an organizational meeting, a talk by an FBI deputy regarding math jobs, and a talk by a previous graduate of HPU's 3-2 engineering program.

New Initiates - Blaise La Madrid, P. Collin Paran, Madeline Ruhl, Hannah Gisela Schuett, and Nathan Thomas White.

IA Alpha – University of Northern Iowa

Chapter President – Adam Feller; 35 Current Members; 5 New Members

Other Fall 2012 Officers: Renee Greiman, Vice President; Shaina Steger, Secretary; Lucas Thomas, Treasurer; and Mark D. Ecker, Corresponding Secretary and Faculty Sponsor

Our first fall KME meeting was held on September 26, 2012 at Professor Ed Rathmell's house where we enjoyed Professor Rathmell's vegetation maze after our regular business meeting. Student member Shaina Steger presented her paper entitled "Three Geometric Conjectures" at our second meeting on October 24, 2012 at Professor Mark Ecker's home. Student member Allison Meier addressed the fall initiation banquet with "Analysis of Violent Crime Statistics." Our fall banquet was held at the Old Chicago Restaurant in Cedar Falls on December 5, 2012 where five new members were initiated.

New Initiates - Travis Buhrow, Elizabeth Johnson, Jesse Moeller, Tanner Rollefson, and Deidre Shea.

IA Delta – Wartburg College

Chapter President – Daniel Mysnyk; 38 Current Members

Other Fall 2012 Officers: Adam Kucera, Vice President; Nicole Boesenberg, Secretary; Alyssa Hanson, Treasurer; Dr. Brian Birgen, Correspond-

ing Secretary; and Dr. Joy Becker, Faculty Sponsor

Our chapter enjoyed a number of social events. We had our usual fundraising booth at the Wartburg College Homecoming Renaissance Fair where we sold egg cheeses. We also held a Bowling for Primes event, in which students tried to knock down a prime number or pins or get a prime score in each frame.

IL Zeta – Dominican University

Chapter President – Lisa Gullo; 40 Current Members

Other Fall 2012 Officers: Ivonne Machuca, Vice President; Claudia Ramirez, Secretary; Azucena Bahena, Treasurer; and Sara Quinn, Corresponding Secretary and Faculty Sponsor

The Illinois Zeta Chapter of KME operates together with Dominican University's Math Club. Thus, the above officers are members of KME or Math Club (or both) and the below activities were prepared by both groups. This past fall semester we continued with the lecture series that began in the fall of 2011. One of the events in the lecture series was a panel discussion about REUs and internships, where the panelists were Dominican University math majors who participated in such programs over the summer. The other event in the lecture series this fall was a talk given by a former DU undergraduate student who is now working towards a PhD in engineering. In addition to those events, we designed t-shirts that we plan to wear on Pi Day this March, and had an end-of-the-semester pot luck game night.

IL Theta – Benedictine University

Chapter President – Natalia Poniatowska; 15 Current Members

Other Fall 2012 Officers: Betsy Williams, Vice President; Trisha Russo, Secretary; Gabe Rodriguez, Treasurer; Dr. Thomas Wangler, Corresponding Secretary; and Dr. Anthony DeLegge and Dr. Jeremy Nadolski, Faculty Sponsors

KS Alpha – Pittsburg State University

Chapter President – Julie Oswald; 25 Current Members; 15 New Members

Other Fall 2012 Officers: Jean Coltharp, Vice President; Danielle Frey, Secretary; Dale Brauer, Treasurer; Tim Flood, Corresponding Secretary; and Cynthia Woodburn, Faculty Sponsor

KS Beta – Emporia State University

Chapter President – Rachel Peterson; 49 Current Members; 10 New Members

Other Fall 2012 Officers: Yinhao Du, Vice President; Keely Grossnickle, Secretary; Amy Bretches, Treasurer; Connie Schrock, Corresponding Secretary; and Brian Hollenbeck, Faculty Sponsor

We had dinner and initiation early in the semester. One of our service

projects was to work as volunteers to feed the homeless at a shelter called Abundant Harvest. Another service we provided was to help proctor at ESU's annual mathematics day. At one of our programs we watched "The Final Smack down: Differentiation vs. Integration." Our December trip to Kansas City was fun as we went to Linda Hall Library on UMKC Campus to view the rare math books. It was followed by dinner and an improv show at Comedy City.

KS Epsilon – Fort Hays State University

Corresponding Secretary – Jeffrey Sadler; 6 New Members

New Initiates - James Beard, Aimee Overmiller, Allison Schley, Shelby Smith, Kaylee Sotelo, and Aidan Winblad.

KY Alpha – Eastern Kentucky University

Chapter President – David Doyle; 10 Current Members

Other Fall 2012 Officers: Ryan Whaley, Vice President; Rebecca Thiem, Secretary; Johnathan Binder, Treasurer; Pat Costello, Corresponding Secretary and Faculty Sponsor

Our chapter hosted its first annual Sudoku Competition. It was a great success. Both students and faculty participated. Faculty member Shane Redmond, was the first person to complete the puzzle. The first student to finish was Fei Cui.

KY Beta – University of Cumberlands

Chapter President – Rufus Deron Higgins; 22 New Members

Other Fall 2012 Officers: Joanah Renner, Vice President; Bethany Bargo, Secretary; Sheena Jackson, Treasurer; Dr. Jonathan Ramey, Corresponding Secretary; and Dr. John Hymo, Faculty Sponsor

Along with the Mathematics and Physics Club and Sigma Pi Sigma, the department had a Christmas party with about 27 people in attendance on December 7.

MA Beta – Stonehill College

Chapter President – Lauren Hinchey; 16 Current Members, 9 New Members

Other Fall 2012 Officers: Kelsey Roberts, Vice President; Olivia Almeida, Secretary; and Timothy Woodcock, Corresponding Secretary and Faculty Sponsor

Massachusetts Beta rounded out the fall semester by sponsoring a pizza party on the last day of classes, inviting all mathematics majors. Good food and mathematical camaraderie were enjoyed by all that attended. During the final-exam period, the student members of the Chapter voluntarily staffed a number of drop-by help sessions, open to all students preparing for final exams in calculus.

New Initiates - Emily Dumont, Andrea Monterotti, Katherine Osgood, Morgan Russo, Gina

Sheehan, Sarah Sherman, Abby Singer, Kelly Spencer, and Matthew Tardiff.

MD Beta – McDaniel College

Corresponding Secretary – Spencer Hamblen; 7 New Members

New Initiates - Michael Byrne, Kristine Harjes, Zachary Heckle, Le Huong Hoang, Jeffrey Kane, Zachary Littrell, and Jeffrey Norton.

MD Delta – Frostburg State University

Chapter President – Kevin Loftus; 25 Current Members; 10 New Members

Other Fall 2012 Officers: DeVonte' McGee, Vice President; Debbie Wiles, Secretary; Meghan Voelkel, Treasurer; Mark Hughes, Corresponding Secretary; and Frank Barnet, Faculty Sponsor

The first fall meeting of the Maryland Delta chapter featured a presentation by chapter secretary Debbie Wiles on her research carried out during the summer while she was a McNair scholar at the University of Maryland. Her project involved identifying and encouraging mathematical talent among students attending community colleges. Our October meeting was divided between watching some fun mathematics videos and developing plans for a math department T-shirt for our students. In mid-October, KME students helped the Mathematics Department during FSU's annual Majors' Fair. Late in the month, we had a very successful bake sale. Dr. Frank Barnet of the Mathematics Department presented a lecture during our November meeting concerning the motions of objects in a rotating space station. By the end of the term, a fantastic mathematics themed T-shirt had been designed and was ready for distribution. We benefitted greatly from the artistic talent of Meghan Voelkel (treasurer) and the computer graphics skills of Debbie Wiles.

New Initiates - Jeffrey Coleman, Chris Colwander, Zach Crawford, Ryley McBride, Philip Rose, Jennifer Scudder, Andrew Sisler, Brian Umbel, Michelle Welch, and Jake Wigfield.

MD Epsilon – Stevenson University

Chapter President – Kellie Forsyth; 34 Current Members; 12 New Members

Other Fall 2012 Officers: Harriet Adutwum, Vice President; Rebecca Wong, Secretary; Bud Schuster, Treasurer; and Dr. Christopher E. Barat, Corresponding Secretary and Faculty Sponsor

The annual initiation ceremony was held on October 16, 2012 in Knott Hall on Stevenson's Greenspring Campus. The featured speaker was Rachel Bauer, a member of the first group of MD Epsilon initiates in 2005 and currently a teacher at Pikesville High School in Pikesville, MD. During the Fall term, several members of the Chapter were among the team of students and faculty that designed an official T-shirt for Stevenson Mathematics majors.

New Initiates - Harriet Adutwum, Michelle Alejandro, Jimmy Brown, Gabriella Forte,

Justin Grynovicki, Kaitlyn Jones, Stephanie Laufert, Jamie Matlock, Jasmine McCullough, Upendra Paudel, Chris Snyder, and Acacia Squires.

MI Beta – Central Michigan University

Chapter President – Marie Ermete; 10 Current Members; 17 New Members

Other Fall 2012 Officers: Megan Haske, Vice President; Jessica Willson, Secretary; Anthony Pochini, Treasurer; and Sivaram K. Narayan, Corresponding Secretary and Faculty Sponsor

During the academic semesters KME met once every two weeks. Recruiting new members went very well. Seven new members were initiated in the spring of 2012. During the spring and fall semesters members raised money through a used book sale held jointly with other student organizations in the department. KME members designed and sold travel mugs and t-shirts for Pi day (March 14). The money raised from these events and membership dues was used for buying pizza on meeting days and for conducting the initiation ceremony. Four KME members and faculty advisor attended the Michigan Undergraduate Mathematics Conference (MUMC) at Sienna Heights University on March 3, 2012. Below is a list of additional activities. Dr. Susan Cooper gave a talk on “Conway’s Mathematical Games.” This talk was given at the KME Initiation Ceremony, which took place on April 22, 2012. Dr. Christine Phelps gave a talk on “Systematically Studying and Improving Mathematics Teaching.” This talk was held on April 12, 2012. Marie Ermete gave a talk on her NSF-LURE project at MUMC on March 3, 2012. Dr. Sukanya Basu gave a talk titled, “On the Connection between Quadratic Maps, Tent Maps and Cantor Set.” This talk was held on November 15, 2012. Dr. Rajarshi Dey gave a talk on November 29, 2012 on “Some interesting problems involving probability.” Troy Klingler and Karleigh Cameron gave talks on their summer research on October 12 and November 1. Dr. Narayan gave a 20-30 minute talk almost every meeting during spring and fall 2012 on various topics in mathematics and its applications. Eight members formed three teams and took part in the 18th Annual Michigan Autumn Take Home (MATH) Challenge on November 3, 2012. On December 1, 2012, three members took part in the William Lowell Putnam Mathematical Competition.

New Initiates - Jairo Coronado, Abram Demski, Daniel Demski, Marie Ermete, Kenneth Goward, Megan Haske, Raschelle Holmes, Troy Klingler, James Kowalski, Emily Lehmann, KelliAnn Lewis, Sarah Mok, Ashley Moon, Keith Novak, Anthony Pochini, Storm Shriver, and Jessica Willson.

MI Delta – Hillsdale College

Chapter President – Megan Moss; 40 Current Members, 19 New Members
Other Fall 2012 Officers: Abigail Loxton, Vice President; Andrea Hay,

Secretary; Viktor Rozsa, Treasurer; and Dr. David Murphy, Corresponding Secretary and Faculty Sponsor

During the fall 2012 semester, we initiated new members, attended a performance of the play “Proof” by a local community theatre, and enjoyed a wonderful Christmas dinner prepared for the faculty and students by our officers.

New Initiates - Anders David Berggren, Devin Creed, Domenic DiGiovanni, Arena Govier, Mitchell G. Irmer, Cody D. Jessup, Hayley Johnson, Alex Kane, Kallie Kennedy, Amy Kerst, Mary Proffit Kimmel, Ayla M. Meyer, Matthew Roland Raffin, David Evans Roach, Samuel Ryskamp, Jacob K. Stratman, JoAnna Waterman, Brett Wierenga, and Yilin Zhang.

MI Epsilon – Kettering University

Chapter President – Jessi Harden (A Section); 186 Current Members, 16 New Members

Other Fall 2012 Officers: Ryan McGuire, President elect; Bryan Coburn (A Section) and Starla Walters (B Section), Vice Presidents; Derek Hazard and Michael Steinert (A Section), and Shanoor Amin (B Section), Secretaries; Keishawna Baker (A Section), Treasurer; Boyan N. Dimitrov, Corresponding Secretary; and Ruben Hayrapetyan (Section A) and Ada Cheng (Section B), Faculty Sponsors

Kettering University as usually enjoys an active KME Society life. In the Summer and Fall 2012 Dr. Hayrapetyan and Ada Cheng offered the traditional Pizza/Movie noon meetings, with one on August 9th at 12:20 in the room AB 2-225. The movie "Galileo's battle for the heavens" is a story was full of history of Italy, the Catholic Church and Vatican's fight with the scientists if the Renaissance. It contains surprisingly many discoveries in Mathematics, Physics and Astronomy due to Galileo's work. The new initiation ceremony for 26 new KME chapter members took part on August 24. As usual, the dinner and the bright initiatives of Dr. Hayrapetyan to offer smart mathematical-logic mini competition between groups of family members and students brought fun and unforgettable moments for the participants. The scientific mathematics Seminar on Control Theory continued in Summer and Fall 2012, despite the fact that Prof. Hayrapetyan was on vacation and sabbatical; he is the initiator and main presenter/lecturer of this Seminar. Amazingly, Professor Hayrapetyan makes this seeming difficult and complicated matter to look easy, understandable, and touchable. It is pleasure, and joy to see how these things allow multiple applications in various hot areas as Biomathematics, Statistics, Optimization, etc. Every year Kettering University recognizes its best teachers, scientists and administration workers with appropriate awards. Our colleague, professor of CS and KME member, Dr. Peter Stanchev got the “Distinguished Researcher Award” for his excellent research records and activities; our

colleague Nancy Stock received the “Distinguished Teachers Award” for her excellence in teaching mathematics, and the KME corresponding secretary, Professor Boyan Dimitrov received the “Tutt Award for Innovation in Teaching” in honor of his achievements and successful teaching Applied Mathematics - Probability and Statistics with the latest modern technical tools: computers, computer programs and in the well equipped Applied Mathematics computer lab. We consider these awards as an appreciation of our continuous support for improvement of student’s education, our profound impact on the involvement of Kettering students into the contemporary technology of application of mathematical knowledge in engineering practice, in everyday’s life, and in research. In the Fall Kettering University hosted the 12th High School Mathematics Olympiad on December 1, 2012. Here is the explicit report of Prof. R. Hayrapetyan, our KME sponsor for Section A students: First Place: Mayank Patke from Okemos, Michigan is a senior and attends Okemos High School; Second Place: Kyungmo Ryu from Birmingham, Michigan is a junior and attends Detroit Country Day School; Third Place: Nevin Mital from Rochester Hills, Michigan is a sophomore and attends Rochester Adams High School; Fourth – Eighth Place: (In alphabetical order) Phillip Bonnevill from Metamora, Michigan is a senior and attends Iron River Christian Academy. Hirsh Jain from West Bloomfield, Michigan is a senior and attends International Academy. Zachary Obsniuk from Livonia, Michigan is a freshman and attends Winston Churchill High School. Samuel Tenka from Ypsilanti, Michigan is a junior and attends Early College Alliance at Emu. Alan Xu from Ypsilanti, Michigan is a junior and attends Detroit County Day. The competition consists of six challenging problems and has a time limit of four hours. The problems range from "mind-benders" that require little mathematical skills to problems that require the knowledge of geometry, trigonometry and beginning calculus.

New Initiates - Steven Dixon, Nathan J. Dwarshuis, Hayley Hanchett, Andrew A. Heller, Raymond L. Hyder, Amy Keith, Mark M. Kovalcik, Lixi Liu, Kevin W. Lucka, Heather J. Mahon, Cassidi Metzger, Sean M. Regan, Logan P. Rowe, Alexander J. Stachowski, Emily M. Thompson, and Benjamin S. VanZoest.

MO Alpha – Missouri State University

Chapter President – Rebecca Wood; 24 Current Members, 25 New Members

Other Fall 2012 Officers: Rachel Siemen, Vice President; Sarah Kramer, Secretary; Marissa Mullen, Treasurer; and Jorge Rebaza, Corresponding Secretary and Faculty Sponsor

The KME Annual Picnic was held on September 18, 2012. The following seminars were held during the fall semester: October 3, 2012—Kevin

Mickus (Geology, MSU) on geophysics and mathematics; October 26, 2012—Kevin Evans (Geology, MSU), on applications of math and statistics in geology; and November 13, 2012—Sarah Kramer and Williams Jones, senior seminar projects. The KME Social was held on December 7, 2012 with a Secret Santa gift exchange, soda, snacks, and games.

New Initiates - Jacob Anderson, Julie Barnum, Matthew Branson, Elena Castanada, Zachary Deskin, Joseph Dillstrom, Zachary Easley, Allison Grigsby, Jacqueline Harrington, Jeani Van Hoecke, Nolan Ingersoll, Dayton Kizzire, Shucen Liu, Hillary Mitchell, Jamie Orlando, Hayley Osman, Andrew Riggs, Austin Shearin, Kayla Smith, Jesse Speer, Brittany Street, Anna Tripi, Tristen Wentling, John Wilcox, and Amanda Yeager.

MO Beta – University of Central Missouri

Chapter President – Amy Billups; 25 Current Members, 10 New Members
Other Fall 2012 Officers: Matt Slack, Vice President; LeighAnn Sherry, Secretary; Alex Card, Treasurer; Tifini Gast, Historian; Rhonda McKee, Corresponding Secretary and Faculty Sponsor; and Steve Shattuck and Dale Bachman, Faculty Sponsors.

New Initiates - John Loren Brookman, Julie Cronin, Kevin Damazyn, Janine Decker, Tifini Gast, Yu-Hsuan Ho, Russell Michal, Erica Teevan, Kate Wanjiku, and Thomas Yoder.

MO Epsilon – Central Methodist University

Chapter President – Megan Davidson; 12 Current Members, 9 New Members

Other Fall 2012 Officers: Novy Foland II, Vice President; Kristen Bailey, Secretary; Kayla Leeser, Treasurer; and Pam Gordy, Corresponding Secretary and Faculty Sponsor

MO Theta – Evangel University

Chapter President – Joshua Forsman; 14 Current Members; 5 New Members

Other Fall 2012 Officers: Elizabeth Baumeister, Vice President; Don Tosh, Corresponding Secretary and Faculty Sponsor

Meetings were held monthly. In October we held a special meeting for KME at Homecoming, where members old and new were able to mingle. We recognized Dr. Glenn Bernet, the charter corresponding secretary for MO Theta, by giving him a tablet computer in appreciation of his 50 years of service to Evangel and KME.

New Initiates - David Annas, Joe Hadinger, Rachael Krawczyk, Chastyti Brooke Neighbors, and Caitlynn Junette Rouse.

MO Kappa – Drury University

Corresponding Secretary – Carol Browning; 9 New Members

New Initiates - Maria Baquerizo, Brooke Foster, Tyler Jenkins, Robert Longley, Juan Matheus, G.W. McElfresh, Shelby McMurray, Jacquelyn Nguyen, and Chengda Xin.

MO Nu – Columbia College

Corresponding Secretary – Dr. Kenny Felts; 5 New Members

New Initiates - Michael Brown, Ashley Bullock, Marli Hayes, Ashley Wager, and Jillian Wilson.

MS Alpha – Mississippi University for Women

Chapter President – Leigh Ellen Barefield; 7 Current Members, 1 New Member

Other Fall 2012 Officers: Tshering Sherpa, Vice President; Menuka Ban, Secretary; and Joshua Hanes, Treasurer, Corresponding Secretary and Faculty Sponsor

During the fall semester 2012, we participated in Operation Christmas Child, preparing five shoeboxes full of toys and school supplies for needy children.

NC Epsilon – North Carolina Wesleyan College

Corresponding Secretary – Bill Yankosky, 4 New Members

New Initiates - Elizabeth Cobb, Sherry Leanna Fann, Bishal Karanjit, and George Zachary Moore.

NE Beta – University of Nebraska Kearney

Corresponding Secretary – Dr. Katherine Kime; 4 New Members

New Initiates - Seul Ki Lee, Aaron Scholl, Chevy Smith, and Qiao Song.

NE Delta – Nebraska Wesleyan University

Chapter President – Alex Whigham; 13 Current Members

Other Fall 2012 Officers: Laura Booton, Vice President; Jayme Prenosil, Secretary and Treasurer; and Melissa Erdmann, Corresponding Secretary and Faculty Sponsor

This autumn the Nebraska Wesleyan KME chapter enjoyed a game night, a panel about summer internships and REUs by NWU students, a talk by a University of Nebraska math graduate student, Tom Clark, about the powerful software program Geogebra, and a joint holiday party with the Computer Science and Physics clubs. Our president Alex Whigham juggled for us at the game night and at the holiday party. The mathematics and physics carols at the holiday party were a success, and a good time was had by all.

NJ Delta – Centenary College of New Jersey

Corresponding Secretary – Kathy Turrisi

The Delta New Jersey Chapter elected three officers to work as a team (Johanne Barthelemy, Brittany Howel, and Kim Kopesky). They are the president's circle and will coordinate with Chapter advisor Kathy Turrisi and Linda Ritchie. In the fall 2012 semester, the Chapter did the following: research for Moravian College Student presentation; collected change in jars to anonymously donate to someone who is need (Christmas Jar book

by Jason Wright); and new members were invited to join the Delta Chapter of NJ. Professor Kathy Turrisi is opening up a free math tutoring center for the town. KME students will provide free tutoring along with members of Delta Kappa Gamma, a Professional Society of Educators.

NY Iota – Wagner College

Corresponding Secretary – Marisa Scarpa; 3 New Members

New Initiates - Samar Alwani, Anthony Gambino, and Carl Sinagra.

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

Chapter President – Daniel Barone; 20 Current Members

Other Fall 2012 Officers: Elyse Capozza, Vice President; Anthimos Michael, Secretary; Thomas Fallon, Treasurer; and Dr. James B. Peters, Corresponding Secretary and Faculty Sponsor

Our annual banquet, where we initiate new members and announce departmental awards, takes place in the spring. This year, the banquet is April 14th. We have a former student give a talk at the banquet on some mathematical topic or career opportunities. This year, the talk is about getting teaching certification in two areas.

NY Nu – Hartwick College

Chapter President – Ashley Hunt; 13 Current Members, 1 New Member

Other Fall 2012 Officers: Jessica Bentley, Vice President; Rhianna Morgan, Secretary; Alyssa Failey, Treasurer; and Ron Brzenk, Corresponding Secretary and Faculty Sponsor

NY Omicron – St. Joseph’s College

Chapter President – Alex Deritter; 25 Current Members, 22 New Members

Other Fall 2012 Officers: Sal Alfredson, Vice President; Mercedeas E. Jordan, Secretary; Steven Bates, Treasurer; Dr. Elana Reiser, Corresponding Secretary; and Dr. Donna Marie Pirich, Faculty Sponsor

This semester the NY Omicron chapter raised money through bagel sales to support the student relief fund at our school that provides support for victims of Hurricane Sandy. Members have also continued volunteering at our Saturday morning math clinic tutoring local high school students.

New Initiates - Allison M. Barbagallo, Carl W. Baurle, III, Jeffrey N. Behounek, Allison R. Brauner, Phillip V. Cangro, Stephanie R. Carrera, Lauren D. DiNapoli, Colleen L. Fitzsimons, John A. Hirdt, Tina F. Kyroglou, Robert J. Mancuso, Thomas J. McKenna, Julianne M. Miller, Samantha M. Olson, John P. O’Rourke, Gabrielle June Peragine, Jennifer L. Rice, Kelsey A. Rice, Eric R. Ruhoy, Sara E. Schmidt, Ashley N. Skilton, and Thomas E. Smith.

NY Pi – Mount Saint Mary College

Corresponding Secretary – Lee Fothergill; 11 New Members

New Initiates - William Callahan Biersack, Mark Botta, Alicia K. Conklin, Kristene Alecks Elia, Ashley Marie Elmendorf, Margaret M. Fallon, Alexander Florez, Sarah Kelleher,

Ericka Knox, Christina Marie Sayegh, and Taylor R. Walton.

NY Rho – Molloy College

Chapter President – Amanda Kovacs; 25 Current Members, 15 New Members

Other Fall 2012 Officers: Natallie Kourywad, Vice President; Joanna Mantone, Secretary; Alfeen Hasmani, Treasurer; and Dr. Manyiu Tse, Corresponding Secretary and Faculty Sponsor

During the fall 2012 semester, the New York Rho chapter raised \$1,500 for Lupas Alliance in September; had three members doing independent research and presenting at the KME convention in April; and the entire chapter is participating in the Relay for Life in April.

New Initiates - Madlyn Brandstetter, Jessica Buonfrisco, Samantha Burke, Samantha Doria, Marie Esposito, Thomas Ferrari, Deanna Giovinco, Crysta Gizzi, Allison Jerz, Kelly Kiesling, Rebecca O'Reilly, Connor Ryall, Casey Schnabel, Renee Smucker, and Delmi Velasquez.

OH Epsilon – Marietta College

Chapter President – Misty Hussing; 20 Current Members

Other Fall 2012 Officers: Evan Winklmann, Vice President; and John Tynan, Corresponding Secretary and Faculty Sponsor

OK Alpha – Northeastern State University

Chapter President – Rho Middleton; 58 Current Members, 11 New Members

Other Fall 2012 Officers: Blane Burge, Vice President; Anna Faina, Secretary; Ryan Berkley, Treasurer; and Dr. Joan E. Bell, Corresponding Secretary and Faculty Sponsor

Our fall initiation brought eleven new members into our chapter. At our meetings we worked on problems from *The Pentagon*. We had several speakers this year. Gregory Davis, an actuary at BlueCross BlueShield of Oklahoma, gave a very interesting talk about the actuary field. Those attending his presentation found out that an actuary is part super-hero, part fortune-teller, and part trusted advisor. Our second speaker was our own KME member Miranda Sawyer. Miranda participated in a NSF-REU (A Research Experience for Undergraduates) at Rose-Hulman Institute of Technology during the summer of 2012. Miranda's presentation summarized the research done by her group. The title of her talk was: Robust Flux Balance Analysis: Integrating Mathematics, Biology, and Computer Science to Study a Cell's Metabolism. Miranda also talked about the experience of participating in an NSF funded REU. The last meeting of the year was the annual Christmas party for KME members, math majors, and math faculty.

New Initiates - Harlie D. Adams, Connor L. Allen, Dakota D. Beller, Emily M. DeMoss,

Sonny J. Downing, Steven G. Feather, Mary M. Harper, Amanda E. Hartman, Devin J. Johnson, Keeli A. (Garrouette) Jordan, Natalie G. Mayberry, JeAnna M. Philpot, Steven J. Sly, Caleb A. Stubbs, Callie A. Taylor, and James T. Townsend.

OK Epsilon – Oklahoma Christian University

Corresponding Secretary – Ray Hamlett; 10 New Members

New Initiates - Alyssa Dickerson, Corrie Hays, Shannon Joyner, Timothy Kagoya, Kyle McCallum, Jean Pierre Mutanguha, Katherin Portwood, Luke Sandhop, Arlette Sangwa, and Dianne Uwacu.

PA Beta – La Salle University

Chapter President – Dominick Macaluso; 18 Current Members

Other Fall 2012 Officers: David Comberiate, Vice President; Olivia Shoemaker, Secretary; Daniel Bowers, Treasurer; and Dr. Stephen Andrilli, Corresponding Secretary and Faculty Sponsor

La Salle University's KME Chapter generally works in tandem with our Math Club (Janet Fierson, Faculty Moderator) in hosting events and activities. In Fall 2012, the KME chapter and the Math Club sponsored a Movie Night ("Good Will Hunting") on September 19, participated in a Day of Service (helping to address issues in computer labs at St. Athanasius School in Philadelphia) on September 29, hosted a guest lecture ("Back to the Future: The Exponential Function in Calculus") by Dr. Eric Key from the University of Wisconsin-Milwaukee on October 2, and conducted a Holiday Fundraiser from December 3-7, 2012. We also sent a delegation of six KME/Math Club students to the JMM (Joint Mathematics Meetings) in San Diego, CA from January 8-12, 2013, and two of these students presented posters at the undergraduate poster session there.

PA Epsilon – Kutztown University

Corresponding Secretary – R.S. Schaeffer; 14 New Members

New Initiates - Rebekah E. Aston, Sarah E. Brown, Catelyn M. Ciccozzi, Danielle F. DelPriore, Luke D. Eshbach, Ronald R. Flicker, Zachary P. Jessell, Eric S. Koch, Brendan Lackman, Mathew M. Martello, Andrew S. Marth, Jennifer L. O'Brien, Megan M. Roberts, and Christopher S. Savo.

PA Eta – Grove City College

Corresponding Secretary – Dale L. McIntyre; 2 New Members

New Initiates - Michelle Shimrock and Jesse Showalter.

PA Theta – Susquehanna University

Corresponding Secretary – Kenneth Brakke; 10 New Members

New Initiates - Joseph Antonides, Herman De Hann, Hilary Grube, Tyler Haussener, Christopher Howard, Matthew Knerr, Shannon Lavelle, Daniel Muller, Keisha Neidrich, and Allison Sample.

PA Kappa – Holy Family University

Chapter President – Gidget Mantelibano; 10 Current Members; 5 New

Members

Other Fall 2012 Officers: Emily Anick, Vice President; and Sister Marcella Wallowicz, CSFN, Corresponding Secretary and Faculty Sponsor

In collaboration with the Math Club, the honor society members hosted its 6th annual Evening of Mathematical Suspense in November, 2012. The Halloween-themed event is in the form of a Math Murder Mystery/Dinner Theatre in which participants solve math problems in order to obtain the clues to solve the murder mystery. Approximately 20 students participated, enjoying pizza and other refreshments. Current members and the candidates for the Spring 2013 initiation participated in a peer math tutoring program at the University. Each candidate tutored for 20 hours during the Fall 2012 semester.

New Initiates - Rebecca Gaetani, Sheridan Goodwill, Timothy McCarthy, Benjamin Savidge, and Livia Yang.

PA Lambda – Bloomsburg University of Pennsylvania

Corresponding Secretary – Elizabeth Mauch; 6 New Members

New Initiates - Louisa Andrew, Kelly Barko, Kristie Darrah, Allison Mack, Brooke Shannon, and Genne Tunney.

PA Mu – Saint Francis University

Chapter President – Phuong Minh Do; 64 Current Members; 13 New Members

Other Fall 2012 Officers: Ryan Knee, Vice President; Elise Lofgren, Secretary; James Shiring, Treasurer; Dr. Peter Skoner, Corresponding Secretary; and Dr. Katherine Remillard, Faculty Sponsor

At the 19th Annual Science Day held November 19, KME members served as session moderators for faculty making presentations, and moderators, judges, scorekeepers, and timers for the Science Bowl; a total of 442 high school students and 39 teachers from 26 area high schools attended.

New Initiates - Shannon Adams, Christopher Albright, Emily Basile, Mallory Cortis, Ryan Ickes, Nicholas Lassak, Christina Leid, Greg Mountain, Becky Peer, Ashley Turnbull, Margaret Waldron, Naiyi Wu, and Frank Youmbi.

PA Pi – Slippery Rock University

Chapter President – Ryan Slean; 15 Current Members; 2 New Members

Other Fall 2012 Officers: Kaila Kramer, Vice President; Amanda Goodrick, Secretary and Treasurer; Elise Grabner, Corresponding Secretary; and Richard Marchand, Faculty Sponsor

New Initiates - Ryan Slean and Michael Tasota.

PA Tau – DeSales University

Chapter President – Michael P. Russo; 7 Current Members

Other Fall 2012 Officers: Kelsey R. Foster, Vice President; Joseph A. Marlin, Secretary; Tripty Modi, Treasurer; and Bro. Daniel P. Wisniewski,

O.S.F.S., Corresponding Secretary and Faculty Sponsor

SC Epsilon – Francis Marion University

Corresponding Secretary – Damon Scott; 8 New Members

New Initiates - Steven Maxwell Biggs, Matthew Ryan Bowen, Ashlee D. Crook, Rachel Gaster, Dalton Gress, Rachal King, Danielle Parker, and Ryan Widejko.

TN Alpha – Tennessee Technological University

Corresponding Secretary – Andrew Hetzel; 35 New Members

New Initiates - Ashley Allred, Blake Berny, Kyle Bieze, Mary Bontrager, Tandy Carmichael, William Caruthers, Alexander Cleveland, Christa Cody, Elvis Encalada, Brian Floyd, Andrew Gardner, Sarah Gray, Zachary Gray, Philip Griggs, Scott Hill, Kristen Hines, Erica Hohne, Tyler Jones, Robert Lindstrom, Anna Litchford, Kevin Lutz, Joshua Moser, Bradley Norris, Alexander Otts, Alexander Palentyn, Hieu Pham, Stephanie Poole, Steven Raines, Joshua Riggs, Dominic Robe, Andrew Tompkins, Adam Trapani, Joshua Walker, Joshua Webb, and Makenzie Wright.

TN Beta – East Tennessee State University

Corresponding Secretary – Robert Gardner; 18 New Members

The Tennessee Beta Chapter member and former president, Lindsey Fox received an ETSU Student-Faculty Collaborative Grant to support work on her Honors-in-Discipline thesis. Chapter member and former secretary Jessica Lunsford participated in the Mathematical and Theoretical Biology Institute at Arizona State University and the Shenandoah Undergraduate Mathematics and Statistics (SUMS) Conference at James Madison University during 2012. Her poster won an award at the SUMS conference. Chapter member and former president Jessie Deering was invited to present part of her Honors-in-Discipline thesis at the "Posters at the Capitol" event in Nashville, TN. She participated in an REU program in Mathematics and Algebra at Auburn University during summer 2012. She has been awarded a prestigious National Science Foundation (NSF) Graduate Research Fellowship which will cover her tuition and include a stipend for three years as she does Ph.D. work at the University of Nebraska-Lincoln. UNL will match the NSF offer after her first three years of graduate study. She currently has several research papers submitted for publication and one paper to appear: "On Anti-Waring Numbers," in the Journal of Combinatorial Mathematics and Combinatorial Computing. Chapter member William Jamieson also participated in the REU program in Mathematics and Algebra at Auburn University during summer 2012. He received honorable mention by the NSF Graduate Research Fellowship Program. He was awarded a GAANN Graduate Fellowship by the University of Nebraska-Lincoln to fund his pursuit of a Ph.D. at UNL. He has several research papers submitted for publication and one paper which is to appear. In fact, he and Ms. Deering are coauthors of "On Anti-Waring Numbers." In ad-

dition, Mr. Jamieson and Ms. Deering are scheduled to be married on June 8, 2013! At the ETSU Mathematics and Statistics Honors Banquet held on April 18, 2013, 18 new TN Beta members were initiated: Kristen Bales, Catherine Below, Andrew Boghozian, Andre Campbell, Laura Chambers, James "Dustin" Chandler, David Elliot, Jenna Brooke Estep, Aaron Gray, Samuel Green, Shelley Goodson, Zachary Helbert, Jennifer Houser, Joseph McNeil, Brittany Munro, Lisa Stacy, Qi Tang, and Elizabeth R. Williams. With these new members, the cumulative membership of the TN Beta chapter tops 800. New officers were elected to serve during academic 2013-14 as follows: President: Dustin Chandler; Vice-President: Chelsea Herald; Secretary: Aaron Gray; and Treasurer: Jennifer Houser

TN Gamma – Union University

Chapter President – Rachel Carbonell; 30 Current Members

Other Fall 2012 Officers: Caroline McConnell, Vice President; Andy Archer, Secretary/Treasurer; David Clark, Historian/Webmaster; Michelle Nielsen, Corresponding Secretary; and Matt Lunsford, Faculty Sponsor

TX Alpha – Texas Tech University

Corresponding Secretary – Magdalena Toda; 12 New Members

New Initiates - Kelsey Burke, Nathan Conroy, Alexander Hagedorn, Casey Hausenfluke, Michael W. Johnson, Kathryn McKeever, Erica McKinzie, Saba Nafees, Ronald (Alex) Rieke, Shelby Salazar, Jonathan Tran, and Jesus Vega.

TX Gamma – Texas Woman's University

Corresponding Secretary – Mark Hamner; 17 New Members

New Initiates - Blair Benefield, Stephan Chavful, Holly Emery, Natalie Erwin, Graciela Garcia, Allyssa Kelley, Cory Lee, Celena Lipscomb, Margaret Mayfield, Lorena Munoz, Taylor Olivarez, Angela Otto, Audrey Parker, Kayla Rivero, Laura Villa, Carolyn Vincent, and Hanna Wodajo.

TX Iota – McMurry University

Corresponding Secretary – Dr. Kelly McCoun; 9 New Members

New Initiates - Jordan Carter, Cristina Roxana Dita, J. Logan Gage, Ryan Gattis, Zachary Leverton, Blair Mauldin, Melissa Vickers, Kari Wilson, and Cody Winter.

TX Kappa – The University of Mary Hardin-Baylor

Corresponding Secretary – Peter H. Chen; 6 New Members

New Initiates - Morgan Boudreaux, Kelsey Janis, Michelle Johnson, Brittney King, Benjamin Valot, and Loren Watson.

TX Mu – Schreiner University

Corresponding Secretary – Stefan Mecay; 9 New Members

New Initiates - Colby Adolph, Mark Andre, Maria G. Diosdado, Lindsay Fox, Chris Grantham, Tayler Hobberlin, Joseph Kuenz, Jocelyn Machis, and Kathrine McDaniel.

VA Gamma – Liberty University

Corresponding Secretary – Dr. Tim Van Voorhis; 14 New Members

New Initiates - Natalie Benet, Joshua Cromwell, Melody Cropanese, Karen den Dulk, Harold Haldren, Nathan House, Ye-Eun Jung, Hannah Kirse, John Laborde, Derek Lenzen, Winston Leslie, Michael Stearns, Jonathan Susman, and Sarah Wallace.

VA Delta – Marymount University

Chapter President – Matthew Villemarette; 33 Current Members

Other Fall 2012 Officers: Myriam Joga, Vice President; Matthew Villemarette and Myriam Joga, Secretaries/Treasurers; William Heuett, Corresponding Secretary; and Elsa Schaefer, Faculty Sponsor

WI Gamma – University of Wisconsin-Eau Claire

Chapter President – Kaisey Garrigan; 45 New Members

Other Fall 2012 Officers: Meghan Christenson, Vice President; Cassandra Dale, Secretary; Lindsay Alger, Treasurer; and Dr. Carolyn Otto, Corresponding Secretary and Faculty Sponsor

New Initiates - Samantha Barr, Olivia Barron, Amy Bauer, Katie Beck, Mitchell Berton, Matthew Bowe, Yeng Chang, Kimberly Charles, Jonathan Dintzner, Lauren Draayer, Craig Dowdy, Jessica Dulli, Natalia Emberson, Lindsey Fickler, Zachary Forster, Melanie Gager, William Gelhaus, Candace Giwojna, Matthew Graveen, Andrew Gulotta, Kayli Hareldson, Matthew Heath, Mei Jing Ho, Elizabeth A. Holmes, Tom Jancik, Se Yeon Kim, Matthew Krochmalski, Alexander Lasiuk, Riley A. LaTour, Kathryn Litzau, Justin Mabin, Jacob Marynik, Ryanne McNurlin, Quinn Mosher, Chao Pang, Ryan Rypel, Allen Sandberg, Jessica Schrom, Jennifer Schulte, Conrad Simmering, Karen Sjoberg, Jacob Steltenpohl, James Truchinski, Avery VanGaard, and Katie Zimmerman.

Active Chapters of Kappa Mu Epsilon

Listed by date of installation

Chapter	Location	Installation Date
OK Alpha	Northeastern State University, Tahlequah	18 Apr 1931
IA Alpha	University of Northern Iowa, Cedar Falls	27 May 1931
KS Alpha	Pittsburg State University, Pittsburg	30 Jan 1932
MO Alpha	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 Mar 1935
NM Alpha	University of New Mexico, Albuquerque	28 Mar 1935
IL Beta	Eastern Illinois University, Charleston	11 Apr 1935
AL Beta	University of North Alabama, Florence	20 May 1935
AL Gamma	University of Montevallo, Montevallo	24 Apr 1937
OH Alpha	Bowling Green State University, Bowling Green	24 Apr 1937
MI Alpha	Albion College, Albion	29 May 1937
MO Beta	University of Central Missouri, Warrensburg	10 Jun 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 Jun 1941
MI Beta	Central Michigan University, Mount Pleasant	25 Apr 1942
NJ Beta	Montclair State University, Upper Montclair	21 Apr 1944
IL Delta	University of St. Francis, Joliet	21 May 1945
KS Delta	Washburn University, Topeka	29 Mar 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 Jun 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 Apr 1957
CA Alpha	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 Apr 1965
AL Epsilon	Huntingdon College, Montgomery	15 Apr 1965
PA Zeta	Indiana University of Pennsylvania, Indiana	6 May 1965
AR Alpha	Arkansas State University, Jonesboro	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	Dominican 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 Mar 1971
KY Alpha	Eastern Kentucky University, Richmond	27 Mar 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 Apr 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 Apr 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 Sep 1978
IL Theta	Benedictine University, Lisle	18 May 1979
PA Mu	St. Francis University, Loretto	14 Sep 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 Mar 1985

NE Delta	Nebraska Wesleyan University, Lincoln	18 Apr 1986
TX Iota	McMurry University, Abilene	25 Apr 1987
PA Nu	Ursinus College, Collegeville	28 Apr 1987
VA Gamma	Liberty University, Lynchburg	30 Apr 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 Apr 1990
CO Delta	Mesa State College, Grand Junction	27 Apr 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 Apr 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 Mar 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 Apr 1997
MI Delta	Hillsdale College, Hillsdale	30 Apr 1997
MI Epsilon	Kettering University, Flint	28 Mar 1998
KS Zeta	Southwestern College, Winfield	14 Apr 1998
TN Epsilon	Bethel College, McKenzie	16 Apr 1998
MO Mu	Harris-Stowe College, St. Louis	25 Apr 1998
GA Beta	Georgia College and State University, Milledgeville	25 Apr 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 Mar 1999
PA Pi	Slippery Rock University, Slippery Rock	19 Apr 1999
TX Lambda	Trinity University, San Antonio	22 Nov 1999
GA Gamma	Piedmont College, Demorest	7 Apr 2000
LA Delta	University of Louisiana, Monroe	11 Feb 2001
GA Delta	Berry College, Mount Berry	21 Apr 2001
TX Mu	Schreiner University, Kerrville	28 Apr 2001
NJ Gamma	Monmouth University, West Long Branch	21 Apr 2002
CA Epsilon	California Baptist University, Riverside	21 Apr 2003
PA Rho	Thiel College, Greenville	13 Feb 2004
VA Delta	Marymount University, Arlington	26 Mar 2004
NY Omicron	St. Joseph's College, Patchogue	1 May 2004
IL Iota	Lewis University, Romeoville	26 Feb 2005
WV Beta	Wheeling Jesuit University, Wheeling	11 Mar 2005
SC Epsilon	Francis Marion University, Florence	18 Mar 2005
PA Sigma	Lycoming College, Williamsport	1 Apr 2005
MO Nu	Columbia College, Columbia	29 Apr 2005
MD Epsilon	Stevenson University, Stevenson	3 Dec 2005
NJ Delta	Centenary College, Hackettstown	1 Dec 2006
NY Pi	Mount Saint Mary College, Newburgh	20 Mar 2007
OK Epsilon	Oklahoma Christian University, Oklahoma City	20 Apr 2007
HA Alpha	Hawaii Pacific University, Waipahu	22 Oct 2007
NC Epsilon	North Carolina Wesleyan College, Rocky Mount	24 Mar 2008

CA Zeta	Simpson University, Redding	4 Apr 2009
NY Rho	Molloy College, Rockville Center	21 Apr 2009
NC Zeta	Catawba College, Salisbury	17 Sep 2009
RI Alpha	Roger Williams University, Bristol	13 Nov 2009
NJ Epsilon	New Jersey City University, Jersey City	22 Feb 2010
NC Eta	Johnson C. Smith University, Charlotte	18 Mar 2010
AL Theta	Jacksonville State University, Jacksonville	29 Mar 2010
GA Epsilon	Wesleyan College, Macon	30 Mar 2010
FL Gamma	Southeastern University, Lakeland	31 Mar 2010
MA Beta	Stonehill College, Easton	8 Apr 2011
AR Beta	Henderson State University, Arkadelphia	10 Oct 2011
PA Tau	DeSales University, Center Valley	29 Apr 2012
TN Zeta	Lee University, Cleveland	5 Nov 2012
RI Beta	Bryant University, Smithfield	3 Apr 2013