PACE IS...

Program for Acceleration in Careers of Engineering – Monmouth Branch March 2003

Science Forum Participants: (L-R) Alex Merced, Brandon Batista, and Joseph Okafor

Inside This Issue

Science Forum Shows Realities of Science

By Silvano Brewster

Staff

This year's Science Forum featured several interesting projects - research into hydroponics, web site design, a solar cooker, database design, and a communications circuit. It also illustrated some realities of science.

The Science Forum was held on March 1 and March 15. Brandon Batista compared the growth of peapods fed with differing nutrients. His project was in an area of science called hydroponics, the growth of plants in nutrient solutions. Joseph Okafor created a database to track donations made to PACE Monmouth. Alex Merced designed a web site that describes how to build a computer. Wariz Anifowoshe and Edward Areus built a solar cooker. A solar cooker is a box constructed to enable the cooking of food using sunlight. Brittany Gladney built a PFM lightwave transmitter and receiver. These are circuits that transmit and receive sounds via light.

The Science Forum as an event has been improving over recent years. The presentations this year were very good, with participants producing professional looking Powerpoint slides or informative displays. The talks were well received and generated a lot of questions and discussions.

Some projects were not completed on time or didn't work completely at the time they were presented, which illustrates a reality that scientific discoveries do not always come about according to a timetable. However, in engineering, the success of a project is due as much to proper planning and time management as to a good design. This is an important lesson to be learned from the Science Forum. Students who did not quite finish promised to continue to work on their projects until they were completed.

The Science Forum is an annual showcase of student research and design projects. Students work under the guidance of a staff advisor over several months. Emphasis is placed on following a structured process, rather than on producing an output. Participation in the Science Forum is voluntary, but is required for students wishing to qualify for a PACE Book Grant award in their senior year. It's an invaluable experience. Students learn skills that they will use repeatedly in college and on the job. This year's participants will be recognized at the annual banquet in May. ❖

Silvano Brewster is a PACE - Monmouth staff member and has been a member of the Science Fair/Science Forum committees for many years.

Wave Generation and Shaping - A Fourier Point of View

By Brandon Batista
Student

Energy, in the form of electrical waves, can be radiated to distant places. These radiated waves can be used to transmit information. The spectra of this transmission varies since its modulation can have many forms to include AM, FM, and PM. Amplitude modulation (AM) is the simplest form of modulation. It is the most widely used modulation method with both double-sideband and single-sideband versions being common. The carrier waveforms in AM signals are frequently represented with periodic waves. Fourier series provide a frequency domain model for periodic signals. Any periodic signal can be represented as a sum of sinusoids. A periodic function of time $\boldsymbol{x}(t)$ having a fundamental period To can be represented as an infinite sum of sinusoidal waveforms. This sum of sinusoids is known as a Fourier series, and may be written in several forms, to include: (1) the sine-cosine form, (2) the amplitude-phase form, and (3) the complex exponential form.

The purpose of this article is to show how Fourier series can be used to represent complex periodic functions into a series of simple functions. No matter how complicated a function is, a wave that is periodic - that means with a pattern that repeats itself - consists of the sum of many simple waves. Since sine and cosine functions are periodic, Fourier used trigonometry to represent complicated periodic waves as summation of simple waves. Therefore, Fourier series give expansions of periodic functions in terms of trigonometric functions. As we break down a complicated wave $\boldsymbol{x}(t)$ into a series of simple waves the number of harmonics of the partial sums of the simple waves are increased up to a point where the Fourier series representation converges to the original shape of the signal $\boldsymbol{x}(t)$. A graphical representation of this process will illustrate that as the number of harmonics (simple waves) increases, the shape of the resulting wave will show ripples. We will also use computer technology to study the effect of these ripples on the final Fourier series representation and the impact on computation time.

But, how do we break a complicated wave down into simple waves? With Fourier analysis, we can use one of three possible techniques: (1) the sine-cosine form, (2) the amplitude-phase form, or (3) the complex exponential form. The sine-cosine form is probably one of the forms most commonly used in the analysis of spectral waveforms. The basis of this method is to recognize the lowest frequency component which is present in the waveform, other than a DC term or constant component

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Staff Profile: Ernest Heath, Jr.

By Silvano Brewster
Staff

Ernest A. Heath, Jr. is the lead instructor for both the Algebra II/Trig and Electrical Engineering classes. He also serves as a Science Forum advisor and runs the PACE – Monmouth Essay Writing Contest. He has a strong commitment to teaching and learning, both within and outside of PACE.

A son of Monmouth County, Ernest was born in Long Branch and grew up in Atlantic Highlands and Middletown. He has a long family history in the area. One of his maternal great-grandmothers was a Daughter of the Northern Delaware Nation (Lena LenapeTribe). One of his paternal great-grandfathers, Clinton Heath (half Songhai-Senegalese and half Cherokee), started a black community within Middletown after the Civil War. Clinton and his Cherokee-Princess wife brought family and friends from North Carolina to the Red Hill Road area. He and his Minister-brother Calvin co-founded the Clinton Chapel A.M.E. Zion Church in Middletown. He worked for the railroad and ran a family farm in the area where Kings Highway and Route 35 now intersect. Clinton's daughter, Bertha Clara, dedicated the Heath Wing of the Tatum Park Activity Center as a tribute to her parents. The Heath Wing has been where Monmouth County has kicked off its annual African American history month celebrations for many years. It was Bertha who told Ernest about PACE and encouraged him to volunteer.

Ernest graduated from Middletown Township High School (now Middletown North) and from Stanford University with a degree in Math and minors in Physics and Pre-Medical Studies. He received a Masters degree in Engineering-Physics and Systems Sciences from the University of California at San Diego and minored in Mathematics and Economics. He has continued his education both formally and informally ever since and has plans to pursue a doctorate. He has been accepted into several doctoral programs. He has held a variety jobs around the country and currently works as the Lead Operations Specialist at ILEX in Shrewsbury.

Ernest is in his tenth year as a PACE instructor. In addition to Algebra II and EE, he has taught Senior Engineering and has served on the Governing Body as both Math Coordinator and Engineering Coordinator. He's been a chair of the Science Forum Committee and has served on various other PACE committees. In 1997, the students voted him Staff Person of the Year. Of PACE, Ernest has said, "I love the opportunities that PACE provides the community to help itself excel and progress."

He has numerous interests and hobbies. He speaks both French and German fluently. He is interested in Christian Spiritual development, sports, photography, American History, Political Science, Law, and many other things. ❖

Silvano Brewster is a PACE – Monmouth staff member.

Thunderstorm 2

By Antoinette Evans
Student

Strong,
Firm I stand.
Protecting those insides.

The wind,
Sharp as knives.
I cry.

Sometimes shifting,
In my standard location.
The rough hands and evil eyes,
Push and pull me about.

I get swallowed ,
By dark blue sharks.
But then it soon,
Leaves me alone.

Stubbornly,
I yell back to the storm,
"You won't take me,
For I am strong in heart".

Rejoice, rejoice,
Is what I will do.

When the
Malevolent heavy gray,
Returns to a
Joyous light blue.

Miss Evans is a sophomore at Old Bridge High School.

Congratulations!

to: ***Michael Chin and Mayra Caceres. They had a beautiful baby girl: Gabriella Mei - Leun Chin. December 4, 2002, 4 pounds 11 ounces***

to: ***Paul Claisse and Ivonne Diaz-Claisse. They had a beautiful baby girl:. Emma Ariana Claisse, 8 pounds 11 ounces, March 7, 2003, 20 ½ inches.***

Especially for the PACE Students

By Uneeda Williams
Staff

Math should not be the only reason that you come to PACE!

Engineering should not be the only reason that you come to PACE!

PACE has many other things to offer, but that's only if you choose to pursue them. Consider these other things "opportunities". Do you recognize opportunities when they are placed before you? Do you take advantage of them?

I've heard students complain that PACE is like a "sixth day of school", yet some of you don't realize the value of this program. In addition to math and engineering, many aspects of PACE will help prepare you for life. Whether you choose to pursue a career in engineering or not, you will have to work hard at whatever you do. Dreams just don't come true; you have to make them come true.

Don't just sit around and think that opportunity is going to come knocking on your door. Recognize opportunity and go after it. Opportunities multiply as they are seized. Raise your hand in class. Ask those questions that no one else wants to ask. Participate in discussions. Take the initiative. Think AND reach outside the box. Do the things that others are afraid to do. Do the things that others won't do. Get involved.

Dr. Johnnetta B Cole said, "Anybody content with mediocrity is destined for failure". Don't just settle for less. There is a whole world out there filled with opportunity, and you can have just as much of it as you want. Are you ready to go get it? Why not start now?

By the way – If you don't know who Dr. Johnnetta B Cole is, take the opportunity to go to the Internet and look it up. ❖

Uneeda Williams is a PACE staff member.

Announcements

PACE-Monmouth Open House – April 12th

On Saturday, April 12, 2003 PACE Monmouth will hold an Open House from 8:30am until 12:30pm. If you are an 8th grader or high school student interested in a career in Science or Engineering, or an industry professional interested in volunteering, come out and spend a day with our PACE students, parents and staff and get the PACE experience!

During the Open House visitors will be able to:

- sit-in on the Eye-Opener session
- participate in math and engineering classes
- mingle with staff and students during breaks
- receive student application materials.

Study Assesses Racial Differences in Student Attitudes Regarding Academic Achievement

By John M. Jones

Staff

A recent report issued by the Minority Student Achievement Network (MSAN) finds that African-American and Hispanic student attitudes regarding academic achievement are not significantly different from their White and Asian counterparts. This finding contradicts beliefs held by some that the current academic achievement gap is the result of a lack of desire to achieve on the part of African-American and Hispanic students. The report, released in November 2002, examines the aspirations and motivations of students across ethnic lines. The study is part of an on-going nationwide research into the causal factors behind the academic achievement gaps between African-American and Hispanic students vs. White and Asian students.

The study - conducted between November 2000 and January 2001 - surveyed 40,000 Middle School and High School students across 15 school districts in Illinois, Michigan, Massachusetts, Ohio, California, New Jersey, North Carolina, Wisconsin, Virginia and New York. The study revealed:

- Students across all racial groups stated to a reasonably equal degree that their key motives for hard work in school are preparation for college success, interest in getting a good job, and a desire to learn.
- Parents also play a critical role in motivating student achievement. Roughly 60% of each group said that when they work hard they do so "to please or impress parents."
- In contrast to other groups, African-American and Hispanic students indicated they work best when teachers encouraged them to work hard as opposed to demanded it.
- African-American and Hispanic students reported less understanding of the reading material and lesson plans covered by their teachers in class, as compared to White and Asian students, despite spending the same amount of time on homework as White students (Asian students spend roughly half an hour more on homework, compared to the other groups.)
- Although the students surveyed were from middle-class and upper-middle-class school districts, White and Asian students, nevertheless, had more books and computers at home, were more likely to have both parents living together, and typically had parents with more years of formal schooling, than did African-American and Hispanic students.

The study is significant in that, for many categories, it showed no real differences across racial/ethnic lines in terms of student motivational factors for learning. However, it did highlight that African-American and Hispanic students indicated they respond best to encouragement from their teachers, leading to one conclusion that relationship building within the classroom is critical to closing the achievement gap. Furthermore, the home environment (access to learning tools, support and involvement of parents, etc.) is another key factor in the scholastic success of African-American and Hispanic students.

By examining student attitudes and perspectives, educators hope to better understand some of the complex dynamics underlying the lower academic achievement of African-American and Hispanic students. Although it has sparked much debate as to whether or not it will be successful, the federal No Child Left Behind Act of 2001 requires states to measure academic achievement results along racial and ethnic lines and to take action to alleviate disparities. It is believed that a combination of both sociological and educational strategies is needed in order to combat the problem.

Survey Results and additional findings from the MSAN report are available at: http://www.msanetwork.org/research.asp.

A full analysis of the research can be found at: http://www.ncrel.org/gap/ferg/

John M. Jones is a PACE staff member.

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AT&T Caribbean Club
AT&T HISPA
AT&T Pioneers
Brookdale Community College
Hewlett-Packard
National Starch & Chemical Foundation
Northrop-Grumman Corp.

PACE – Monmouth Calendar

March 29, 2003	PACE YDC All-Branches Math Bowl
April 12, 2003	Open House
April 22nd – 25th, 2003	College Tour
May 17, 2003	Graduation & Awards Banquet

Parental Involvement is Crucial to Children's School Success

By Dr. Deborah P. Harrell

Staff

Volumes of research have been conducted relative to the critical role of parental involvement in children's success in school. Research consistently shows that there is a strong correlation between parent involvement and a child's academic success. In an article entitled, "The Future of High School Success: The Importance of Parent Involvement Programs" Hickman (1995) states that, "about one-half to two-thirds of the variance in student achievement could be accounted for by home variables rather than school variables."

Hickman (1995) discusses parental involvement in terms of home-based activities (such as parent home tutoring) and school-based parent involvement (such as parent volunteering and attendance at parent-teacher conferences). Researchers found that home-based variables were at least as important as the school-based variables in accounting for the total amount of student achievement variance. Epstein (1988) places parent involvement into five types: (a) parents providing for the health and safety of their children as well as preparing their children for school (b) the school communicating with parents about school programs and the progress of children; (c) the volunteering of parents in the classroom and attendance at school performances or sports events; (d) parents initiating activities with their child or a child initiating the help through questions: (e) the parents assuming decision making roles.

What are some ways parents can take on a supportive or direct involvement role in their children's academic achievement? Parents can attend school and sports events. They can monitor and review their children's homework or help with editing school reports. They can establish a conversation with the child about the activities of the day, asking the child what they learned or about grades received. Interested parents can engage in "collaborative discovery" (i.e. learning together), perhaps with regard to a favorite subject or a particularly difficult class. They can take on joint tasks, such as building a project, researching data together, and learning to use research tools and store data that can be later referenced and incorporated in a report.

Realizing that not all parents feel comfortable taking such an active role in their children's education, some states have mandated that their school systems develop programs to help parents develop skills and foster conditions at home that support learning. These programs help provide parents with the knowledge of techniques designed to assist children in learning at home, provide access to and coordinate community and support services for children and families, promote clear two-way communication between the school and the family to the school programs and children's progress, involve parents, after appropriate training, in instructional and support roles at school, and support parents as decision makers and develop their leadership in governance, advisory, and advocacy roles.

Some examples of state-mandated programs are Florida's 1973 development of school advisory committees (SACs). Missouri's State Department of Education developed a Parents as Teachers program that helps train parents so that they can teach their own children at home in skills learned at school. Missouri's Success is Homemade program expands the parent involvement from kindergarten through the end of high school. California, Illinois, Tennessee, and Minnesota also have state-mandated initiatives.

In summary, the benefits of parental involvement are immeasurable. It has a strong positive effect on children's attitudes, behavior, and learning. Parents and children have an opportunity to bond and to show interest, while learning and discovering together. Children who have had the benefit of parental involvement in their academic endeavors often perform at significantly higher levels in both the personal and academic areas of their lives.

Dr. Harrell is a PACE staff member

Wave Generation

Continued from page 2

which is independent of time, and to express the spectrum as a series of sine and cosine components which are harmonics of the lowest or fundamental frequency.

It can be shown that with this form one can represent a periodic signal $\boldsymbol{x}(t)$, having a fundamental period $\boldsymbol{T}_0$, as a sum of sines and cosines. The Fourier sine-cosine form reads

$$\boldsymbol{x}(t) = A_o + \sum_{n=1}^{N} (A_n Cos\, n\omega t + B_n Sin\, n\omega t) \qquad (1)$$

$$\omega = 2\pi \mathbf{f}_o = \frac{2\pi}{\mathbf{T}_o}$$

where $1 \le N \le \infty$, is the fundamental angular frequency in radians/second (rad/s), the nth harmonic cyclic frequency (in hertz) is $n\mathbf{f}_o$, and the corresponding angular frequency is $n\omega$. The constant A_o represents the DC term and it is simply the average value of the signal $\boldsymbol{x}(t)$ over one cycle. The parameters A_o, A_n, and B_n can be determined as follows

$$A_o = \frac{1}{\mathbf{T_o}} \int_0^{t_o} \boldsymbol{x}(t) dt \qquad (2)$$

Continued on next page

Wave Generation

Continued from previous page

$$A_n = \frac{2}{\mathbf{T_o}} \int_0^{t_o} \boldsymbol{x}(t) Cos\, n\omega t\, dt \qquad (3)$$

$$B_n = \frac{2}{\mathbf{T_o}} \int_0^{t_o} \boldsymbol{x}(t) Sin\, n\omega t\, dt \qquad (4)$$

where $n \geq 1$. The limits of integration may be changed for convenience, provided that the interval of integration is over one complete cycle. A well known alternative range is from $\frac{-\mathbf{T_o}}{2}$ to $\frac{\mathbf{T_o}}{2}$. This not only preserves the integration over one complete cycle of the fundamental frequency but also can be very useful if the waveform to be analyzed is symmetric about the t = 0 axis.

What follows is an example of an application of the Fourier sine-cosine form: suppose that we are asked to transmit a message with a signal that has the following characteristics:

$$\boldsymbol{x}(t) = \begin{cases} \mathbf{P}, & 0 < t < \frac{\mathbf{T}}{\mathbf{2}} \\ 0, & \frac{\mathbf{T}}{\mathbf{2}} < t < \mathbf{T} \end{cases} \qquad (5)$$

We could use Fourier series to convert $\boldsymbol{x}(t)$ to a more friendly mathematical expression. Using Equations (2), (3), and (4), the parameters A_o, A_n, and B_n can be determined as

$$A_o = \frac{\mathbf{P}}{\mathbf{2}} \qquad (6)$$

$$A_n = 0, \quad n \neq 0 \qquad (7)$$

$$B_n = \begin{cases} \frac{\mathbf{2P}}{n}, & n \ odd \\ 0, & n \ even \end{cases} \qquad (8)$$

The values of A_o, A_n, and B_n given by Equations (6), (7), and (8) are substituted into Equation (1). Then, the resulting sine-cosine form of the Fourier series representation of $\boldsymbol{x}(t)$ can be expressed as

$$\boldsymbol{x}(t) = \frac{\mathbf{P}}{2} + \sum_{n=1}^{N} \frac{\mathbf{2P}}{n\pi} Sin(n\omega t), \quad n \ odd \qquad (9)$$

Equation (9) approximates $\boldsymbol{x}(t)$ with a partial sum of the first *N* harmonics of the waveform. Figure 1 (page 7) shows a graphic representation of $\boldsymbol{x}(t)$ with P = 4, along with approximations for *N* equal to 1, 3, 5, 9, 15, 25, 75, and 151. In each case, the partial sum is superimposed on the original square wave. It can be seen that as the value of *N* (harmonics) increases, the Fourier representation converges to the original shape of the signal $\boldsymbol{x}(t)$. If we carefully look at these graphs in Figure 1, one can observe ripples as *N* increases. It was observed that the amplitude of these ripples does not decrease with *N* increasing *N* (see the case for *N* = 75, and *N* = 151). Thus, as *N* increases, the ripples in the partial sums become compressed toward a discontinuity, but for any final value of *N*, the amplitude of the ripples remains constant. This behavior is known as the Gibbs phenomenon. The average value of the discontinuity has zero area. In practice, a large value of harmonics, *N*, is used to guarantee that the total energy in these ripples is insignificant. It was also observed that as the value of *N* increases, the computation time required to compute the partial sums also increases substantially.

In conclusion, looking at the usefulness of Fourier series, one should not lose sight of the fact that the partial sums of the series provide approximations to the full sum, and that such approximations may be just what one needs to obtain a computationally manageable solution to a problem. Depending on the number of harmonics (simple waves), it could be time consuming calculating the partial sums. Therefore, minimizing the effect of the ripples on the final Fourier series representation could have a significant impact on computational time. Since a large number of harmonics may be needed to guarantee accuracy during transmission, this will have an obvious impact on the cost of computer usage.

For the Fourier series of a sectionally or piecewise smooth function $\boldsymbol{x}(t)$, the lack of uniformity manifests itself in a peculiar way known as the Gibbs phenomenon - as one adds on more and more harmonics, the partial sums overshoot and undershoot $\boldsymbol{x}(t)$ near the discontinuity and thus develop "spikes" that tend to zero in width but not in height. Fourier series provide a very powerful and important method for the analysis, design, and understanding of electronic signals and how they are generated.

Brandon Batista is a junior at Monmouth Regional High School

PACE Is

The PACE Is newsletter is a forum for disseminating news of interest to the PACE family and showcasing the talents and accomplishments of the PACE – Monmouth students. We solicit news, articles, essays, poems, artwork, and photography, especially from students. Please submit contributions via e-mail to newsletter@pace-monmouth.org or by U.S. mail to PACE Is, PO Box 493, Lincroft, NJ 07738.

Back issues of PACE Is can be obtained in PDF format from the PACE web site: www.pace-monmouth.org.

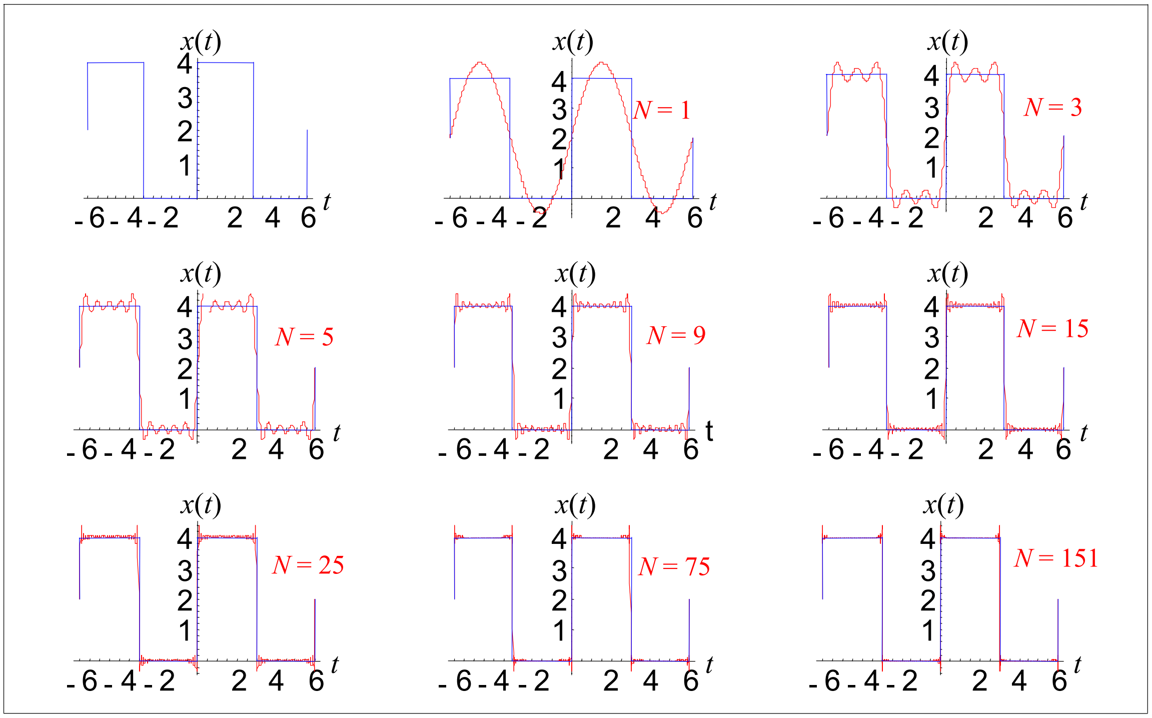

Figure 1: Convergence of the Fourier Series Representation of the Square Wave

Trip to Liberty Science Center

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PACE Is Staff	
Editor	Judith Wheeler
Contributing Reporters	Brandon Batista Silvano Brewster Antoinette Evans Dr. Deborah P. Harrell John M. Jones Uneeda Williams
Photography	Silvano Brewster John M. Jones

PACE - Monmouth at Brookdale Community College
P.O. Box 493
Lincroft, NJ 07738

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