# Mπ The Mathematics and Physics Institute NEWSLETTER

**Director: Elizabeth Stoddard, Ph.D.**
**Associate Director: Richard Delaware, Ph.D.**

**April 1, 2002** **mpi@umkc.edu** **Vol. 16, No. 5**


## OUR 18th YEAR

After surviving the great ice storm of 2002, we enter Spring with palpable relief. This 2001-2002 MPI year we welcomed our new director Dr. Libby Stoddard from Washington University in St. Louis, and a new physics teacher Dr. Russell Clothier from Betheny College in West Virginia. We also welcomed the districts of Hickman Mills and North Kansas City to the MPI program and hope to see some of their students at the MPI next year. Lastly, our secretary Donna Dilse has completed just over her first year with us.

The MPI continues to endure through another change of characters. Believe it or not, this Fall 2002 will be the start of our 19th year and the first in which we can say we existed before our students were born! We'll see you all after the summer, with another year of Calculus, Physics, and preparation for college. Thanks for your support.

## CALCULUS READINESS EXAMS

During the **last weeks of April and the first week of May,** the Associate Director will travel to most of the high schools participating in the MPI to administer the MAA Calculus Readiness Test, a 25 question diagnostic test designed to determine roughly how prepared a student is to take calculus. It covers analytic geometry, algebra and some trigonometry. A score of 12 or above is required to attend the MPI, although occasionally lower scores are accepted, provided a transcript and two recommendations are received, and a personal letter is written to the MPI Director, all **by May 9** this year. (Details will be discussed when the Associate Director makes his visit.)

Of course, this little test is by no means definitive, and in fact, a student's commitment more often determines his or her success at the MPI than a score on one introductory test. However, this test has proved to be effective as long as it is complimented by CAREFUL SCREENING done at individual high schools by counselors and teachers who know the students in question. Let us be clear on this: Students who have all the prerequisite classes and score 12 or more on the test, but who possess no maturity or commitment to hard work will not succeed at the MPI.

## MPI ALUMNI!

### HAVE YOU GRADUATED FROM COLLEGE?

If So
Please Consider Being An
**- ENRICHMENT SPEAKER -**
Contact us at (816) 235-1272
or mpi@umkc.edu

MPI Alumni who have spoken:

| | |
|---|---|
| Doug Bullock | (84-85) |
| Brent Harding | (84-85) |
| Pam Deters/Stephen Koop | (84-85) |
| Seth McMenemy | (88-89) |
| Tony Thornton | (88-89) |
| Mitch Dobson | (89-90) |
| Rachel Allen | (92-93) |

## ODDS AND ENDS

On **January 28 and 29,** our two **Recruitment Days,** we hosted approximately 80 high school juniors and several teachers and counselors, from 8 different high schools: Center Place Restoration, Central, Ft. Osage, Hickman Mills, St. Mary's, Southeast, Truman, and William Chrisman.

**E-mail** received by **Libbi Sparks** on 1-29-02:

"[After attending the MPI Recruitment Days,] it's easy to see why you are a member of the MPI staff as you display similar qualities the program establishes for the students, and for that, I commend you. Keep up the excellent work and thanks again

for keeping me "learning" about WC and the various programs we offer here."

**Brian Schumann**
Assistant Principal
William Chrisman High School

On **February 26**, Libby Stoddard gave an invited talk titled "Powerful Learning Through Elementary Science!" at the Powerful Learning Conference in Kansas City, MO.

On **March 5**, not only, as reported in the last newsletter, did Richard Delaware act as a moderator and judge for the Second Annual UMKC HSCP (High School College Program) Mathematics Competition for high school students, but Libby Stoddard also participated as a judge.

On **March 9**, Sheri Adams gave a talk at the 3rd Annual Missouri Pre-Service Mathematics Teacher Conference, sponsored by Central Missouri State University at the Lake of the Ozarks, MO.

During **March**, Sheri Adams and Libbi Sparks continued to work with a task force made up of the Metropolitan Community Colleges and 6 school districts on the transition in mathematics from grades 9 - 14.

## THE AUGUST 2002 ISSUE

The August I Mπ Newsletter will list the top ten MPI students for 2001-02 and all those receiving awards at our May 9th **Awards Presentation.**

There will also be **IMPORTANT INFORMATION** and advice for the **YEAR 19** class of 2002-2003. TAKE NOTE!

## ENRICHMENTS

### FOLLOW UP

On Friday, **February 15,** Eddie Burris, UMKC Computer Science & Telecommunications, spoke on **"Intellectual Property Rights in the Digital Age (and Careers in Computer Science)."**

Students responded:

- I liked it. It taught us about the rights of artists. I learned what is legal or not. Overall it was good.
- He wants us to gain respect for intellectual property. Intellectual property isn't tangible, it is books, poems, songs, ideas, and anything else that can be copyrighted. Using someone else's intellectual property without the author's consent is a wrong thing and should be discouraged.
- Was very knowledgeable on the subject.

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On Friday, **March 1**, we made a two-part **FIELD TRIP:**

In **one part** of the trip, we toured **UMKC PHYSICS DEPARTMENT LABS** and heard about some of the ongoing research there:

- Professor Jerzy Wrobel's study of semi-conductor properties with Photo-Luminescence.
- Professor Fred Leibsle's study of Metallic and Magnetic films with Scanning Electron Microscopy.
- Professor David Wieliczka showed the undergraduate optics laboratory with some experiments performed by UMKC undergraduates set up.

In **the other part**, we visited the Rare Book Room of the world-class **LINDA HALL LIBRARY OF SCIENCE** (surrounded by the UMKC campus, though independent of it), and examined original editions of historically significant books on mathematics and physics such as:

- Works by Newton (1736 edition) and Leibniz (1684), co-inventors of Calculus
- The first Calculus textbook, written by L'Hospital (1696), and the second by Maria Agnesi (1801 edition)
- Three versions of Euclid's Elements, including the earliest printed version (1482), and first English edition (1570)
- Works by Archimedes, Barrow (Newton's teacher), Boole, Boyle, Coriolis, Descartes, Euler, Galileo, Maclaurin, Simpson, and Wallis, among others

**Students responded:**

- The trip started with a tour of the Linda Hall Library, during which we found out that the library has around/over 40,000 scientific/mathematical journals, with around 26,000 of them current subscriptions. We then visited the Rare Book Room and saw works that have been important in math/science (more on that in my writing assignment). After that we went on a tour of some of the UMKC physics labs and saw a luminescence, electron microscope, and student lab. After this, we had a somewhat meager lunch followed by a brief period of waiting, during which I purchased a cup of hot cocoa, from which my tongue is still slightly burned.

■ I found Galileo's book to be very enriching. Next we went to the physics labs and our minds were broadened with knowledge on lasers and vacuum electron microscopes. Following the physics lab came a gourmet lunch. Yumm...

■ The trip was superb. We were surrounded by a wealth of knowledge both in the library and in the classrooms with the professors. They were all excellent orators and gave us a lot of information to think on. The entire trip was well worth going to.

■ The trip was very interesting especially the physics labs dealing with lasers even thought I don't plan to become a physicist. I loved reading about Marie Agnesi, seeing her accomplishments (the only woman I saw from those days).

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**Writing Assignment:**

After the field trip, students were required to type a response for Calculus credit about the books they personally examined. Here are some **excerpts**:

"I had a blast on our trip to Linda Hall Library. I am still astounded and even proud that I have been exposed to such wonderful pieces of history, and mathematics and physics at the same time."

**Jake Fulcher**

"I had to look up what some of the [mathematical] signs meant so I could begin to understand the equations. The notation they used then is nothing but confusing, but I found it fun; it was kind of like breaking a code...Barrow's definition of a line: 'A line is simply a longitude without latitude.' A very cool quote. I have never really thought of it that way. I fact I don't really remember anyone ever giving me the definition of a line."

**Josh Tanner**

"Not many people can say they saw the first [printed] edition of Euclid. But you know what? Now, I can."

**Matt House**

"I like how he [Newton] phrased his three laws....The first is 'Every body will continue in the state it is in whether it be at rest or whether it moves on uniformly in a straight line unless it be made to alter that by some force impressed upon it.' The second and most used is...'The change or alteration of motion is proportionable to the impressed motive force; and is made according to the direction of the straight line in which that force is impressed." And last but not least is his third law, 'Re-action or resistance is always equal and contrary to action or the actions of two bodies upon each other are always equal and directed the contrary way to another." Now his laws are simplified and said differently and I believe that they lose some of their beauty."

**Chris Nevans**

"...the thing is that math is always the same. It surprised me to see that all of the symbols were still the same and that you could perfectly understand all of the equations. The other thing that surprised me was that the books in English were very easy to read...In [Analytical Institutions by Maria Gaetana Agnesi] a very neat point was made about zero. The book read 'Sometimes we may meet with equations which contain the same quantities on both sides of the mark of equality, and therefore when reduced bring us finally to this conclusion that $0 = 0$.' When I first read this I thought it was quite humorous because such an answer is very obvious. So I finally concluded that this hadn't always been a simple concept."

**Devin Thompson**

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On Friday **March 15**, Daniel Kaplan of Macalester College in St. Paul, Minnesota was our enrichment speaker. His mathematical field is Chaos Theory and his doctorate is actually in biomedical physics. The previous evening at Linda Hall Library of Science he spoke as a guest in their 2002 lecture series. We were then very pleased when he agreed to also address MPI students the next morning, on **THE MATHEMATICS OF SLEEP**. His abstract states: "Our daily lives are organized around our sleep/wake cycle, a rhythm that is so basic that it is not even noticed until it is disrupted by insomnia, jet lag, or shift work. Observations and experiments involving human volunteers show remarkably complex patterns in the rhythm. Simple mathematical models provide a useful way to organize experimental observations, and make startling predictions about how the rhythm can be reset and even stopped."

**Students responded:**

■ We have our own biological clock and operate on around a 25-hour day with two points of equilibrium. After studying the sleep pattern of humans, he showed us a graph of the typical cycle as it rotates. He was very informative and showed us the actual patterns humans have and how we tend to drift.

■ He started off talking about sleep and some of the studies that had been done on it. I thought it was interesting that they would stick people in a room for a year and feed them free and stuff. After that, he started showing us the mathematical models of sleep, and the (somewhat weird in my estimation) ability to send people to the "South Pole" of sleep. This could be a very cool technology for the future.

■ He spoke about experiments done on individuals and how individual bodies have internal time clocks to wake them up. He talked about how an individual who is isolated from actual time can have 33 hour days instead of 24 hours.

■ Presentation of material was very professional & very informative. Interesting topic, I never knew that there was so much mathematics and pattern in the sleep process. Very well done!

■ I really enjoyed it, but I think it made me really tired.

■ I thought it was very informative. Not something I'd do for a living. But it was still fun to hear about how weird people's sleep patterns can be. I especially liked the videos and graphs that were used to illustrate the presentation.

■ Great subject matter. Much better than previous two speakers. Great speaker. He knew what he was talking about and used no bad analogies.

■ The speech was a real snooze (hahaha). The talk was very interesting and I got a lot out of it. Three cheers for sleep.

## UPCOMING

We have not yet scheduled speakers for April 5 and April 19.

Sunday, **April 28,** will be our annual **WORLDS OF FUN PHYSICS DAY.**

Finally, we'll hold our annual **BREAKFAST** on Wednesday, **May 8,** and our **AWARDS PRESENTATION** on Thursday, **May 9,** the last day of MPI classes this year.

## WE HEAR FROM PAST STUDENTS

**Brent Harding (84-85)**
BS Aerospace Engineering
University of Texas – Austin
MS Physical Science
University of Texas - Houston
Orbital Sciences Corporation
Engineer Specialist

**Email** received 3-15-02:

"Unfortunately I have several projects all coming together in the next couple of months, so I won't be able to come out this April [to be an enrichment speaker]. I'm supposed to go to California and Japan to do some customer training, and the dates are currently fluctuating in the early-to-mid April timeframe.

My job at Orbital Sciences Corp. seems to change every day, but here's a brief description of what I'm working on at the moment:

I'm the chief engineer responsible for developing a satellite simulator that is being used to test software that will be loaded on a satellite, as well as train the ground controllers (our customers) who will be operating the satellite after it is launched. The satellite simulator models the behavior of the satellite in response to environmental effects, like gravity or solar radiation, and commands coming from the ground or the onboard computer, such as a command to fire a rocket or rotate part of the spacecraft. With a high fidelity simulator, we can fully test things on the ground before we launch the satellite and make sure everything is functioning properly. Our customers can also test commands before they send them to the real satellite, to make sure that the spacecraft will do what they intend. Currently, we are building satellites for customers in Japan and California, and part of my job is to provide training to these customers on how to use the simulator we've developed. So in the coming months I'll be traveling to Japan and Los Angeles. Orbital Sciences has also demonstrated this simulation to potential customers from Europe and Asia, so I may be spending a lot of time traveling in the near future.

Well, Rebekah [my daughter] is up from her nap, so I better wrap this up. I hope this is what you were looking for. Over the next year, Orbital may be asking me to modify this simulation to support a mission to the asteroid belt. It sounds interesting, so I hope they decide to do it.

I always look forward to speaking at the MPI, and appreciate your invitation. Hopefully I'll be able to come out next year. As always, feel free to contact me if you need anything, and pass along my best wishes to the class of 2002."

**Matt Cianciolo (93-94)**
BS Medical Physics
Creighton University
Currently: University of Health Sciences
College of Osteopathic Medicine

**Reported** 3-7-02 by Jim Cianciolo, Matt's father:

"Matt graduated from Creighton University in the top 10% of his class. He received a two-year scholarship for his Master's degree but only completed one of the two years because he was accepted at the University of Health Sciences, College of Osteopathic Medicine where he is now a third year medical student. Now he is doing a one-

year rotation in New Jersey and has already performed some bone surgeries.

When Matt was at the MPI he found to his surprise that he really liked Physics and did very well in it. It was because of the MPI that Matt is in the position he is in today.

Matt is engaged to be married this summer to another physics major he met at Creighton while he was president of the Physics Club. She now works for NASA as a rocket scientist on the Mars Odyssey Project on a team of only 18 people."

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**Rachel (Cianciolo) Bressman (96-97)**
BS Biology and BS Anthropology
Washington University
Currently: University of Pennsylvania

**Reported** 3-7-02 by Jim Cianciolo, Rachel's father:

"Rachel graduated as valedictorian from Washington University in three and a half years with two degrees [see above]. She is now a veterinarian student at the University of Pennsylvania, and was recently married."

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**Jacqueline Fairley (96-97)**
University of Missouri – Columbia
Electrical Engineering Major

"MPI was extremely beneficial in my pursuit of an Electrical Engineering degree. It allowed me the opportunity to perfect my discipline skills in regards to my study habits, which are essential to be successful in any engineering program."

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**Matthew Lane (99-00)**
University of Missouri – Columbia
Computer Science Major

"Of course, MPI prepared me for higher-level university-style math courses, however, at MPI I got an A while not doing much studying. I attempted to do this at MU, and found that my study habits were not quite up to par. On the other hand, if MPI was much more rigorous, I wouldn't have survived my senior year of high school.

I have found that success in math courses at MU comes from doing the suggested practice problems. As I recall (maybe I'm wrong) the practice problems were not required at MPI. Perhaps there is a way to require completion of practice problems while still placing a large weight of the final grade on the exams. By the way, the calc labs seem to be unique to MPI, and they were an EXCELLENT way to see various applications of calculus."

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**Aaron Ballantyne (00-01)**
University of Missouri – Columbia
Computer/Electrical Engineering Major

"Several things covered in my Calc 2 class we covered in Calc 1 at MPI – very helpful! I learned to anticipate what would be on tests so study time isn't wasted. [The MPI gave me a] chance to meet new people and take challenging courses."

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**Laura Hajj (00-01)**
Exchange student in Germany
Massachusetts Institute of Technology (Fall 2002)

**Email** received 2-24-02:

"Hello everyone. For those of you who don't know me, (1) don't listen to anything that anyone says :), (2) I was at MPI last year and I am currently an exchange student in Germany (it is really cool). I am still in contact with Dr. Delaware, mainly because he was the coolest teacher I ever had, and sometimes I want to know something interesting about math (i.e., fractals, fractals are zoo cool (eh christopher)). Oh yeah, last prerequisite knowledge is... sorry about my weird English. I don't get to speak English so often here and German has really perverted my vocabulary and my sentence structure. I told Dr. D. that he can correct what he wants.. ;)

Anyway, the point of this article is to add a few words of encouragement to you current students (and to say What Up? to you old friends.) So, here I am studying in Germany. I am in a math and science emphasis gymnasium. A gymnasium is like high school plus 2 years college and only certain students can go there (only the "smart kids") and if you get more than 1 F or 2 D's in a year you have to repeat the year. If you do it again then you get kicked out of the school and have to go to a lower (real- or hauptschule) school. So theoretically school here is harder. I don't know. It can be, but in my math and science classes everything is incredibly easy because of the MPI. I learned so much last year (section C) that this year it is difficult to find something new to learn. In my advanced math class we are learning the chain rule, and integrals (I need the practice, but still...). The point of this story is that while you may not notice that you are learning something above and beyond your classmates who get to sleep a bit later, you really are learning more and becoming more sophisticated. I encourage you who want to drop or fall back or are just losing faith that you will survive and the fight will only make you stronger and fit for college. Don't succumb to senioritis and forget everything that you have learned, or just ruin

yourself. Everything that you experience this year will either be forgotten or will help you later in life, until you find another experience from which you can learn. Sure this year isn't everything, but suck the milk dry. Don't miss this opportunity; it will carry you a long way. And don't cause yourself regrets and unjustified agony.

As a last word... good luck everyone. I am really happy to see so many familiar names in the top ten list (congrats!). Good luck debaters (Dustin?, Gibler?, etc.) and academic scholars (Chris?, etc.) at districts. I also encourage you all to study abroad, it is a great opportunity to get rid of all those things about yourself you don't like and to learn so much about everything."

## FINAL 2001-2002 STUDENT IMPRESSIONS

"The best advice I could possibly give to anyone who is thinking of MPI is to not let 'senioritis' hit at all! Just do your work as soon as you get it and you'll do fine. Once you fall behind, even if it's just a little bit, it will start a chain reaction of late papers. You've always heard that a little bit goes a long way, this is especially true for senioritis."

**Johnathon Bender**
Fort Osage High School
Fort Osage School District

"The worst part of MPI has to be mornings. I've always been a person to say, 'I'll just do that in the morning,' but 5:30am comes really fast when you don't fall asleep until midnight."

**Sean Tracy**
Truman High School
Independence School District

"I really do enjoy MPI. I like being in classes where not everything comes easy. At times though, MPI can be frustrating. Tests are hard. Homework is difficult. Sometimes, even lectures are mind boggling. However, we all pull through. We all work together to get things done. I feel good when walking into class, except for the fact I'm usually a minute or two late."

**Dustin Sullivan**
Fort Osage High School
Fort Osage School District

"What is the only place on earth where high school seniors come to school at 7:00 in the morning to learn Calculus and Physics? Why it must be MPI. The place where learning begins early and ends in time to get in a morning game of football. One must remember to stop and enjoy oneself after a rigorous morning of integrals and pressure formulas."

**David Winfrey**
Fort Osage High School
Fort Osage School District

"The MPI has been a good experience for me. I have always been curious about calculus and college physics subject matter, and the teachers are able to keep the lectures very interesting. I enjoy the relaxed college atmosphere. Even though I have never been a morning person, the MPI has become my favorite part of the school day."

**Ben Neal**
William Chrisman High School
Independence School District

"MPI has been a great experience for me. The atmosphere is much different than what I was used to. Working in an environment where every student not only takes education serious, but also finds it exciting as well, has been a real inspiration to me. MPI has been an extreme challenge for me, but I've learned so much attending the courses. I just hope each class after us hangs in there and continually excels. Never give up even when it gets tough and especially when it's the toughest."

**Danielle Cole**
Southeast High School
Kansas City Missouri School District

"The MPI has proven to be a great opportunity for me and was a very helpful insight on some of the things you might experience in college and the future. The MPI prepares you for the many nights of studying and homework you will have but it's all left up to your choice of how you want to do things. The MPI has also helped me become a better planner at how to get things done in a sufficient amount of time. I've gotten so used to the 50 minute test and the usual 15 Physics homework problems that I'm able to do them before time is up. The MPI has definitely prepared me for the future."

**Kenneth Steward**
Central High School
Kansas City Missouri School District

## A SOLUTION TO MATHEMATICS CHALLENGE #72

Recall the problem statement:

Suppose a real number, $x$, satisfies all the inequalities:

$$2^1 < x^1 + x^2 < 2^2$$
$$2^2 < x^2 + x^3 < 2^3$$
$$\vdots$$
$$2^n < x^n + x^{n+1} < 2^{n+1}$$

That is, for all $k = 1,\ldots,n$, the number $x$ satisfies

$$2^k < x^k + x^{k+1} < 2^{k+1}.$$

What is the greatest possible value for $n$?

[From: Gordon Lessells of Limerick University, Ireland, as quoted in Mathematical Chestnuts from Around the World, by Ross Honsberger, MAA, 2001, problem #8, p.277.]

**SOLUTION:**

First we examine the n = 1 case, which restricts $x$ to lie in the common domain determined by the two simultaneous inequalities

$$2 < x + x^2 \quad \text{and} \quad x + x^2 < 4.$$

The left inequality yields:

$$2 < x + x^2$$
$$0 < x^2 + x - 2$$
$$0 < (x - 1)(x + 2).$$

Since $0 = (x - 1)(x + 2)$ for $x = 1$ and $x = -2$, the product $(x - 1)(x + 2)$ is only nonzero where either $x < -2$, $-2 < x < 1$, or $x > 1$. By checking each interval, we find that $0 < (x - 1)(x + 2)$ is only true where either $x < -2$ or $x > 1$.

Similarly, the right inequality yields:

$$x + x^2 < 4$$
$$x + x^2 - 4 < 0.$$

By the quadratic formula we find that $x + x^2 - 4 = 0$ for $x = (1/2)(-1 \pm \sqrt{17})$, and by checking intervals find that $x + x^2 - 4 < 0$ is only true where

$$(1/2)(-1 - \sqrt{17}) < x < (1/2)(-1 + \sqrt{17}).$$

Combining these results we see that the n = 1 case confines $x$ to either of the two intervals:

$$(1/2)(-1 - \sqrt{17}) < x < -2, \text{ or}$$
$$1 < x < (1/2)(-1 + \sqrt{17}).$$

Now examine the n = 4 case inequalities:

$$16 < x^4 + x^5 < 32.$$

Observe first that for $x$ in the interval $(1/2)(-1-\sqrt{17}) < x < -2$ the expression $x^4 + x^5 = x^4(1+x)$ is always negative, hence certainly **not** between 16 and 32. On the other hand, though $x$ is positive in the interval $1 < x < (1/2)(-1+\sqrt{17})$, likewise $x^4 + x^5$ **cannot** lie between 16 and 32 since substituting the larger endpoint $(1/2)(-1+\sqrt{17})$ into $x^4 + x^5 = x^4(1+x)$ yields $10\sqrt{17} - 26 = 2(5\sqrt{17} - 13) < 2(5(4.2) - 13) = 16$.

Finally, note that the particular value $x = 3/2$ lies in the positive n = 1 interval because

$$1 < 3/2 = (1/2)(-1 + \sqrt{16}) < (1/2)(-1 + \sqrt{17}),$$

and 3/2 also satisfies the n = 2 and n = 3 inequalities since

$$4 < (3/2)^2(1 + 3/2) = 45/8 < 8, \text{ and}$$
$$8 < (3/2)^3(1 + 3/2) = 135/16 < 16.$$

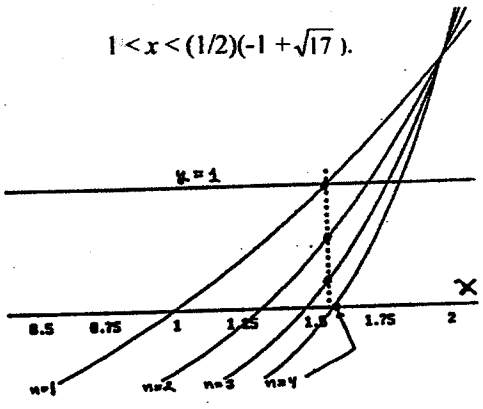
So the greatest possible value of n is 3, attained at least by $x = 3/2$.

**NOTE:** One way to visualize this solution is to rewrite the inequalities as

$$2^k < x^k + x^{k+1} < 2^{k+1} = 2^k + 2^k$$
$$0 < x^k + x^{k+1} - 2^k < 2^k$$
$$0 < (1/2^k)(x^k + x^{k+1}) - 1 < 1$$
$$0 < f_k(x) < 1.$$

Then graph the functions $f_k(x)$ for k = 1, 2, 3, 4 and observe that no point lies on the graphs of all four functions, with y-value between 0 and 1, when $x$ values lie in the (positive) interval

$$1 < x < (1/2)(-1 + \sqrt{17}).$$




## A SOLUTION TO PHYSICS CHALLENGE #63

Recall the problem statement:

Another example of colors seen in nature that are not due to pigment is the pattern of colors seen in oil or gasoline on water. Such spills appear with a pattern of yellow, magenta (pink), and cyan (greenish blue) rings or stripes. Can you think of the physical reason for the appearance of these colors?

**SOLUTION:**

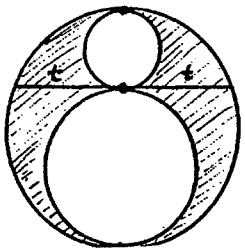
When gasoline is spilled on water, it spreads out to make a thin film. Such thin films appear colorful due to an effect called thin film interference. This occurs when light reflects from both the top and bottom surface of a film. The two light waves will interfere either constructively or destructively, as explained in the last puzzler. But, white light contains all colors (wavelengths) or all 3 additive primary colors as sensed by 3 types of cone cells in our eyes (Red, Green and Blue). When one primary color is missing from white light, a subtractive color [Magenta = White - Green, Cyan = White - Red, Yellow = White - Blue] appears.

In an oily film on water, a set of wavelengths will be missing due to destructive interference of light reflected from the top and bottom surfaces. This occurs when the difference in path-length traveled by the 2 beams of light is enough to make the peaks of light waves from one surface occur with the troughs of those from the other. Which wavelengths will be cancelled out (Blues, Greens, or Reds) then depends on the thickness of the oil film.

As a result, each colored stripe or ring represents a line of equal thickness of the film, similar to how lines on a topographical map signify lines of equal elevation.

## MATHEMATICS CHALLENGE #73

The length of the chord tangent to the inscribed circles as shown is $2t$.




Find the area of the shaded part of the circle in terms of $t$.

[From: Mathematical Discovery, by George Polya, p. 43.]

## PHYSICS CHALLENGE #64

Continuing on the topic of light, why are Polaroid sunglasses recommended for drivers or boaters who want to cut glare from surfaces of roads and lakes?

**Editor/Writer:** **Richard Delaware**

This Mπ Newsletter is typed in Microsoft Word 97 and published five times a year on the first of the month during the months of August, October, December, February and April, at the Mathematics and Physics Institute (MPI), 600 W. Mechanic, Room 224, Independence, MO 64050, Phone: (816) 235-1272, E-Mail: **mpi@umkc.edu**. Please address all correspondence concerning this newsletter to 'Mπ Newsletter'.