Mπ The Mathematics and Physics Institute NEWSLETTER

Director: Richard Waring
Mathematics Coordinator: Richard Delaware

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AS YEAR 9 ENDS

For the first time this year we had our own computer lab, as you have been reading in the Computer Report articles since August. Although we still need 6-9 more machines and some sort of projection device to satisfy our needs, we continue to discover new ways to enhance our teaching by using the computers. For instance, 5 new physics labs were written to make use of the computers as measurement, data-gathering, and data analysis tools to complement our new physics equipment. Next year, 5 more will be written, so that 10 of the 15 physics labs we do each year will involve the computers. Calculus labs have of course been written and refined for both Calculus I and II for two years now.

In contrast to our newfound technical sophistication, we still face the uncertain task of finding replacements for three retiring high school faculty members, although the exact dates of their retirement are now unclear.

At the end of next year, in May 1994, it will be exactly 10 years, 1 Decade, since the MPI began.

CALCULUS READINESS EXAMS

During the week of May 3 the Mathematics Coordinator will travel to each of the six high schools participating in the MPI to administer the MAA Calculus Readiness Test, a 25 question diagnostic test designed to roughly determine 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 an interview with the Director takes place.

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 complemented by CAREFUL SCREENING done at individual high schools by counselors and teachers who know the students in question.

We hope that many of the approximately 130 students who visited us on our Recruitment Day Feb. 17 will decide to take the test.

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! NOTICE !

The August 1 Newsletter will list the top ten MPI students for 92-93 and all those receiving awards at our May 20 Awards Presentation.

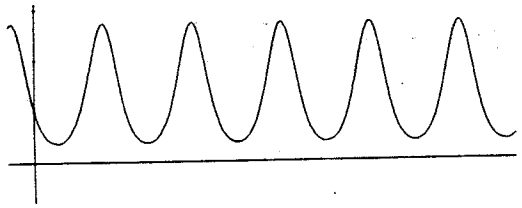
There will also be IMPORTANT INFORMATION and advice for the YEAR 10 class of 93-94. TAKE NOTE!

COMPUTER LABS REPORT

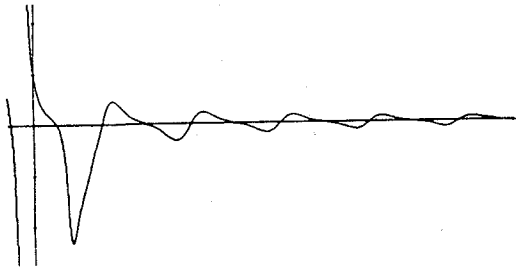
Beginning students, especially in calculus courses, tend to ignore or disregard the assumptions under which the theorems they use are true. And usually they are justified in practice, since only a rare example or homework exercise presents a

situation in which one of the 'ignored' assumptions is NOT met. To address this question in the MPI Calculus II class, we recently assigned a very nice computer laboratory problem from **Discovering Calculus with Derive**, by Jerry Johnson and Benny Evans, (1992), called **A Subtle Example Where L'Hôpital's Rule Seems To Fail.**

L'Hôpital's Rule states that under the right conditions, the ones students tend to gloss over, the limit of a given quotient of functions $f(x)/g(x)$ as x goes to ∞ is identical to the limit of the quotient of derivatives $f'(x)/g'(x)$ as x goes to ∞. In our problem, the given quotient is $\frac{x+\sin x\cos x}{(2x+\sin(2x))e^{\sin x}}$. Since this has the form "∞/∞", it seems that L'Hôpital's Rule applies, so using Derive to take the derivatives of the top and bottom separately, dividing, and letting Derive compute the limit, we correctly get "0", and hence conclude that the given quotient also goes to "0" as x goes to ∞. However, the given quotient, with the easy substitution $\sin(2x) = 2\sin(x)\cos(x)$, simplifies to $\frac{1}{2e^{\sin x}}$, whose graph is below. Clearly, as x goes to ∞, $\frac{1}{2e^{\sin x}}$ oscillates forever between 1/2e and e/2 !



On the other hand, as we see in the graph below, the quotient of derivatives clearly goes to "0" as x goes to ∞ !



Isn't this a contradiction? What's wrong?

The difficulty is that one assumption for L'Hôpital's Rule was ignored, i.e., that when x goes to ∞ we must have $g(x) \neq 0$ for ALL x in a 'neighborhood' of ∞, meaning for ALL $x > N$, where N is some constant. Aha! Since in the second graph we see that $g(x) = 0$ regularly and infinitely often, this assumption is violated. So, L'Hôpital's Rule does NOT apply to the given quotient, and there is really no contradiction here.

A GRAPHICS CALCULATOR TRIAL

In December we arranged with the SHARP corporation to receive 5 of their EL-9300 graphics calculators on loan for a 3 month trial. The mathematics coordinator used one, and the other 4 went to the four students enrolled in both Calculus I and Calculus II. Here are the extended calculator reviews written by two of those students:

"The Sharp graphing calculator was a great instrument for many uses. It helped give me the picture of a function I was working with, especially for the calculus course where pictures are a must. I don't have a computer, so it was nice to have another alternative when I needed the graph of a function. It was also nice because of the small size, I would carry it around with me all the time, unlike a computer. The only other graphing calculator I have used is the TI-81, but I didn't use it more than twice because I didn't know how to use it. The Sharp calculators were much better because the manual was extremely easy to read and understand which made me want to use the calculator more often because I could figure out what to do.

I think MPI should purchase a class set for the students to use at their own leisure. They should be allowed to take them home for additional work that cannot be finished at school. If they can't take them home, it's useless to purchase them when there are already computers available at school."

Kristi Bass
Truman High School
Independence School District

"Introducing the new, the improved, the illustrious Sharp graphing, programmable, do-anything calculator. Is there anything this baby can't do? It reminds me of a Swiss Army knife; so versatile that it probably has everything including a small nuclear device. The only problem is that it is completely useless if you have no idea how to operate it. That is the same problem with most hi-tech calculators of recent birth. They can do most of the same stuff but the question lies in the usability and its user friendliness.

The Sharp is probably easier to use than any other that comes close to comparing with its capabilities. Much of the functions are self-explanatory and easy to find no matter where you are in the different modes. Being able to flip back and forth from the graph mode to the program mode to the real mode with the command buttons at the top ensures that you won't get lost at any time. Little things that made a difference are the way it shows you where the error is and lets you fix it instead of just deleting everything you have on the screen. Programming is easy and easy to use once you get the hang of manipulating the variables to spit out the answer you want. The 'sharp' picture on the text and graph windows provide easy reading and unlike the Casio's, are legible from any angle (when you tip the Casio's the display disappears or dims from sight). The mathematical symbolism and nomenclature is displayed in a way that would mirror handwriting in proper form. For example, the integral problems with upper and lower limits and fractions with horizontal bars and many others. The statistics functions and data entry make it simple to manipulate a set of information into immediately readable graphs or derived units (standard deviation, variance, range, etc.).

The calculus functions are probably the most use to me personally. These functions are missing from the Casio's that I have used. It lets me check the long, written out work that I do just by putting in derivatives or integrals with their limits and checking the final outcome. You can actually see what's going on instead of just a string of numbers that represents the statement. The graphing capabilities are very good and I particularly like the auto-scaling feature. The detail in the picture of the graphs is pretty good as graphing calculators go and the trace function is fairly accurate.

Hopefully, this won't be one of those experiences where you're given a new game and just when you learn how to play, it gets taken away from you. Just within the last few days (since the calculators were returned), I have felt the utter loss of such a vital part of my available resources for working in my Physics and Calculus classes. I know that it will be an incredible help going into college with a calculator that I'm already familiar with and can use fairly proficiently."

Brett Williams
Truman High School
Independence School District

ENRICHMENTS

FOLLOW UP

Both the Feb. 12 and Feb. 26 enrichments were cancelled, the first since the physician speaker was called out of town, and the second due to heavy snow (15+ in.!) In fact, this winter MPI classes have been cancelled 5 times, the most in our 9 years.

On March 12, paleontologist David Frayer from KU spoke on **HOW TO RECOGNIZE THE EARLIEST HUMANS: AUSTRALOPITHECUS AFARENSIS.** Some student comments were:

-- This was an excellent enrichment! Learning about ancient humans and how and where they lived is exciting. It is also neat that there is only a 1% difference in DNA between us and chimpanzees, and that chimps and humans are more closely related than chimps and gorillas. Make it be for 2 hours so he can include more stuff.

-- This enrichment was entertaining as well as informative. I actually found myself thinking about it after class, and discussing it with my friends.

-- I never knew that we were that similar to chimps, but I guess you learn something new every day. He also brought in molds of footprints made by some of the earliest humans.

You could tell they were human prints because there were no hand prints that went along with them, insinuating that they were not quadrapedals, but instead bipedals, or humans.

-- He explained that the boundary between humans and apes is in our method of locomotion and touched upon the physics involved in human feet. It was an interesting presentation.

On March 26 we visited the **KANSAS CITY MUSEUM**, passing through two trucks from NASA containing a mock-up of the Habitation Module and a Laboratory Module for Space Station Freedom, and then saw the Mirror Magic exhibit on optical illusions, kaleidescopes, etc.

UPCOMING

On April 16, as a special enrichment, Paul Braisted, Associate Dean of Engineering at the University of Missouri - Columbia, will speak on **CREATIVITY.** He is appearing as a direct result of knowing a former MPI student, Seth McMenemy (88-89), now having great success at MU.

Brent Harding (MPI 84-85), a former MPI student now an aerospace engineer at McDonnell-Douglas, has agreed to speak on April 23, perhaps about **PUTTING THE GPS (Global Positioning System) INTO THE SPACE SHUTTLE.**

On May 7, civil engineer Shelley Wolff will make her annual visit to discuss **HIGHWAY SLOPE DESIGN**, topping off a week-long calculus project of the same name.

On Sunday May 9, Mother's Day, we'll make our annual trek to **WORLDS OF FUN** amusement park for a day of physics problems.

Finally, we'll hold our **PICNIC/BREAKFAST** at McCoy Park on Wed. May 19, and our **AWARDS PRESENTATION** on May 20, the last day of the MPI this year.

WE HEAR FROM PAST STUDENTS

SONYA SMITH (91-92)
(French Major)

"Well folks, I've finally gotten to writing to you all! I am having a fantastic year in Belgium, though I'm not actually <u>using</u> all those valuable MPI skills I acquired last year, at least not the calc and physics ones. Instead I am learning to survive on my own, and create a new life out of a group of strangers. I have been here now exactly 5 months, have been accepted by these strangers as a friend and as family. Because Lanaken is only a medium-sized town, with a small town attitude, I've even been initiated into its society. I hear stories from my parents about where I was seen shopping, or riding, or eating, or talking ... That, I suppose doesn't change so much, wherever you are!

On an interesting comparison note about the math & science I've seen here, I would say they are about the level of MPI--you can elect to take an 8 hour a week math class that, I believe, covers essentially all the calculus in Calc I & maybe a bit of Calc II, with "other math" mixed in: statistics, matrices, etc., etc. Physics I'm not sure about as I do not have the class, but (for the 'Science Class') this is their 2nd year of 2 hours a week, but I keep hearing the names & seeing the equations I saw last year. The biggest difference is that, because they've always been expected to <u>know</u> the material covered in class, they do, at least at my school!! (What a difference!) I've often smiled at the thought of throwing some of you all, my American teachers, into these classes: where people (everyone) takes notes, are prepared for lessons, and actually pay attention when you speak. That's the atmosphere in my school, and when the teachers throw fits (about the smallest thing) I just wonder what they'd do in the average public high school...

Since it had not previously been required of me before I attended MPI, the pure necessity of studying has, oddly enough, assisted me in learning Dutch & German here in Belgium. The discipline required to study calculus is also necessary in language.

My latest strategy for problem solving comes directly from MPI Calc II. If you don't understand it, or can't solve it, 1) stare at it, pen in hand, 2) fill up reams of paper with attempts at solving it-combining everything you ever learned, 3) sleep

on it & try again tomorrow-it goes better the second time.

MPI was probably the first time I consistently scored quite low on tests. But, in the MPI atmosphere of help & encouragement, I was able to realize that it isn't the end of the world, but, if I start a little earlier studying next time ...

If you would like to print this version of correspondence, spelling mistakes corrected, feel free. If not, my best wishes to MPI '92-'93, especially, and everyone else generally."

RICK TRIMBLE (89-90)
(Electrical Engineering Major)

"Attending MPI actually is what made me decide to go to college. I enjoyed the challenge so much, that it lead me to try electrical engineering. Calculus I at MPI gave me a good solid base for my later courses in mathematics.

The actual teaching quality was much better than most mathematics and physics courses I've had since."

NATE MOORE (87-88)
(BS Electrical Engineering;
Graduate Student-Washington Univ.)

"I am finishing up my job search & debating between 3 companies to take job offers with, i.e. Price Waterhouse (St. Louis), Clark-Richardsen-Bishop Consulting Engineers (St. Louis), and Motorola Corp. (Chicago). I will decide within the week. So, I have to finish up my final semester and will be done w/it."

ERIC MARSHALL (86-87)
(BS Management)

"I am currently a 2nd Lt. in the Air Force and will be promoted in May '93. I now work in a Security Police Squadron, but am attached to a flying squadron. I received my flight wings from the Air Force in Oct. '92. I have been married since May '91 and have no children. There is not much I could suggest about MPI. It was a good program. I don't use much calc or advanced physics in my current field, but the knowledge helped me get into and stay at the Air Force Academy. Say hello to Mr. Nelson for me."

TAMMY PHELPS (88-89)
(Biology Major)

"I believe every high school senior/junior should seize the opportunity to get ahead by going to MPI."

CHAD WAINWRIGHT (91-92)
(Civil Engineering Major)

"I learned not to wait till the night before tests to learn material. I also reviewed material after lectures to help remember and understand it.

As far as problem solving I learned to look at them with a more "open mind" allowing me to see more than one way to solve some problems.

It got me interested in both physics and engineering."

JILL BLAKE (90-91)
(Chemical Engineering Major)

"I will be taking physics courses next term. I have found that MPI provided me a foundation to build on. Therefore, I have been able to understand concepts and terms quicker. I would say I have gained from all of my courses and MPI has helped me a great deal.

...things that I have learned at MPI I have kept with me and use all the time in my current courses.

I like the idea of the finals (at the MPI). I sure hated them when I was there but now I have finals for everything and I really feel at least I got some sort of a hint as to what was to come."

JACQUI MORRIS (90-91)
(Mechanical Engineering Major)

"It is my opinion that the physics instruction at MPI far exceeded that of MU. This could be attributed to class size, and the instructors. Mr. Waring put forth a

very concerned, caring attitude toward each student. I'm also, in hindsight, appreciating that none of the MPI instructors were foreign!

The MPI showed me that time is valuable-there is a direct relation to how much time I spend and what grades I get.

I hope the MPI continues. It provided a safe environment to experience college while in high school."

HOLLY BUXTER (90-91)
(Mechanical Engineering Major)

"MPI was a kind of transition step between high school and college. It was harder than high school, but not as hard as college in that you could communicate with the MPI professors on a much more personable level than most at MU.

It made me appreciate the time and energy the MPI professors spent on the students. They seemed to really care about the students, and if we understood the material. It is very difficult to get that kind of attention at college.

I really didn't appreciate the MPI as much as I should have when I was there. I appreciate it so much more after a few semesters at MU."

JEFF SCHREINER (91-92)
(United States Air Force Academy)

"Sorry I've lost contact over the last few months. I missed the panel by just two days and I haven't really had a chance on leave to get over and see the gang. Life's OK so far. I start Hell Week this week. Which is basically the last week I have before I become a recognized upperclassman. It's not gonna be pretty. School going well so far. It's a lot tougher than what I was expecting or was prepared for. I got a 3.4 last semester and was on the Dean's List. I am now in Multivariate Calculus and am declaring Materials Science as my major. I heard that Tim Thacker (MPI 92-93) is thinking about coming here. Tell him that it's really tough, but it's worth it in the end. I almost left, but looking back now I'm really glad I decided to stick it out. Tell Mr. Waring that I am in the top ten in Physics 110 here, out of about 500 students. Anyhow I just wanted to say Hi and that I'm still alive. I'll try to write again sometime if this actually makes it there and I get a reply. Thanks for everything all of you gave me. I really have used it!"

MARK LAMBROS (89-90)
(Electrical Engineering Major)

"The Calc I teacher at Longview had a habit of making students feel stupid. Mrs. Adams was a very caring and helpful teacher that could motivate students to apply themselves, where my other Calc I teacher came to the point of making students give up.

The classes at MPI made it possible to get through some very rough times (at Longview) with teachers that were hard to get along with.

I still have trouble applying myself to learn, but I'm improving."

FINAL 92-93 STUDENT IMPRESSIONS

"At the MPI, through its unique and intense format, I have gained more knowledge of mathematical and scientific procedures that will aid me through all of my future endeavors."

Deuandara Sysavath
Northeast High School
Kansas City, MO School District

"When I walk into MPI in the morning I ask myself, 'why me?', but upon looking at my grade, I ask myself 'What hath God wrought?'

At MPI one gets the chance to learn about some aspects of college life. MPI teaches that Vivarin has twice as much caffeine as No-Doz, that Mountain Dew has the most caffeine of all the soft drinks, and that sleep is unimportant.

It's almost over! (The Horror! The Horror!)"

Todd Johann
Wm. Chrisman High School
Independence School District

"MPI is a slap in the face to wake up. It has forced me to actually work for a grade, and I have experienced every emotion associated with success and failure."

Andrea Slusser
Wm. Chrisman High School
Independence School District

"Calculus is like an ingrown toe nail; it cuts deep and hurts every time you touch it!"

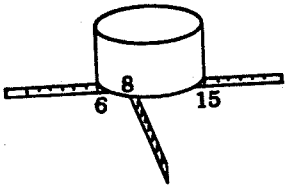
Greg Andrews
Truman High School
Independence School District

A SOLUTION TO MATHEMATICS CHALLENGE #27

Recall the problem statement:

A large cylindrical pot has been set over an open fire on crosspieces of metal bars at right angles and with sharp upper edges marked in inches out from the center, for some forgotten reason.

The pot has been pushed to a precarious position, and from where we are we can see that the circular bottom just intersects the bars at 6, 8, and 15 inch marks, as indicated below:

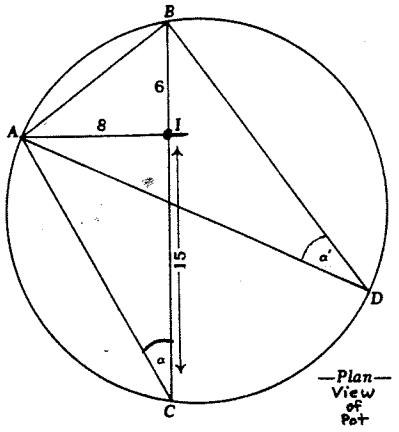


What is the DIAMETER of the pot?

[From: Mathematical Brain Benders by Stephen Barr.]

SOLUTION:

In the plan view of the pot, shown below, I is the intersection of the cross- pieces, AI, BI, and CI are respectively the 8-, 6-, and 15 inch lengths of the crosspieces cut off by the pot, and AD is a diameter of the pot.



Using the Pythagorean theorem:

$$AB = \sqrt{6^2+8^2} = 10$$
$$AC = \sqrt{8^2+15^2} = 17$$

Since $\angle ABD$ is subtended by the diameter AD and B is on the circle, $\angle ABD$ is a RIGHT angle. Next, $\angle\alpha = \angle\alpha'$, because both are subtended by AB. Finally, $\angle AIC$ is also a RIGHT angle. Hence, ΔABD is similar to ΔAIC, meaning $\frac{AD}{AB} = \frac{AC}{AI}$, so,

$$AD = \frac{10 \cdot 17}{8} = 21.25 \text{ inches},$$

the DIAMETER of the pot.

A SOLUTION TO PHYSICS CHALLENGE #18

Recall the problem statement:

Estimate to the nearest power of ten how many home runs were hit in all regular season major league baseball games last year.

SOLUTION:

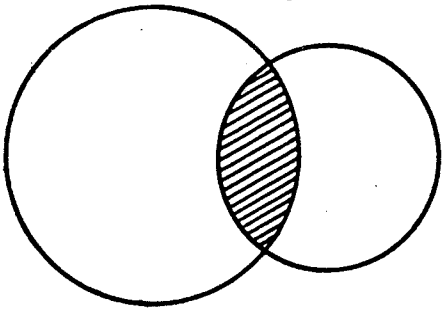
The reasoning used to solve this problem is the same as used on the last physics quiz. First we ask ourself how many major league baseball teams there are: Are there 1, 10, 100, 1000, etc.? There are certainly more than 1, but considerably less than 100. The choice to the nearest power of ten is 10 teams. Then we ask how many players there are per team: Are there 1, 10, 100, etc.? Again the choice is 10 players per team. Then we ask

how many home runs will the typical player hit in a year: Is it 1, 10, 100, 1000, etc.? Again the proper choice is 10 home runs per player. So, the total number of home runs hit to the nearest power of ten is (10 teams)·(10 players/team)·(10 home runs/player) = 10^3 home runs.

MATHEMATICS CHALLENGE #28

The following is culled from the novel MRS. MINIVER:

"She saw every relationship as a pair of intersecting circles.



It would seem at first glance that the more they overlapped the better the relationship; but this is not so. Beyond a certain point, the law of diminishing returns sets in, and there are not enough private resources left on either side to enrich the life that is shared. Probably perfection is reached when the area of the two outer crescents, added together, is exactly equal to that of the leaf-shaped piece in the middle. On paper there must be some neat mathematical formula for arriving at this; in life, none."

Remembering that two circles are rarely equal, what is the mathematical answer to Mrs. Miniver's enigma?

[From: Ingenious Mathematical Problems and Methods by L. A. Graham]

PHYSICS CHALLENGE #19

WINGS ON RACING CARS

Racing cars have gone through a great many changes over the years, some obvious, some subtle. One of the best developments was the addition of a horizontal wing above the rear of the car. When a car with such a wing entered a curve, the driver would tilt the wing forward. Upon leaving the curve, the wing was leveled again. This wing and its adjustments proved very useful in keeping a car on the road in turns, hence allowing much higher speeds there. Were it not for the danger of broken wings resulting in uncontrollable cars on the tracks, these movable wings would still be in use. But safety forced the racers to fix their wings in place.

In either case, movable or fixed wing, how would a wing help in keeping the car on the road?

[From: The Flying Circus of Physics by Jearl Walker]

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