Mπ The Mathematics and Physics Institute NEWSLETTER

Director: Richard Waring
Mathematics Coordinator: Richard Delaware

April 1, 1994 **Vol. 8, No. 5**

OUR FIRST DECADE, AND COUNTING

Ten years ago, in 1984, the MPI was born in direct response to the national report "A Nation At Risk", under the impetus of UMKC and several local Missouri school superintendents. Now, for 10 years, class after class of MPI students, all high school seniors, have persevered through our program and, we hope, gone on to successful college and professional careers. By the end of this 10th year, 474 students will have completed the MPI, an average of 47 students a year. Of these, 301 (64%) were male, and the other 173 (36%) female. As we have reported here before, the overwhelming majority of our graduates have chosen to study mathematics, science, engineering, or medicine, and we are proud to have provided them a solid base in both calculus and physics, as well as some insight into their chosen careers through our enrichment talk series. If our mail is any indication, as you have been reading in this newsletter, they have always found the MPI hard, but rich in experiences, both academic and social. (For instance, see the latest "We Hear From Past Students" in this issue.)

The MPI program has only become stronger each year, and even though technology has recently entered our domain, with computers, physics and calculus software, graphics calculators, and the like, we will NOT lose sight of the fact that the aim is to teach calculus and physics, and that technology should stand in service to that end. The next decade looks bright. We look forward to our 11th class!

CALCULUS READINESS EXAMS

During the week of May 2 the Mathematics Coordinator will travel to each of the seven 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 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 153 students who visited us on our Recruitment Day Feb. 15 will decide to take the test.

MPI E-MAIL ADDRESS:

rdelaware@vax1.umkc.edu

A list of known MPI Alumni e-mail addresses is available on request.

A CHANGE OF CAST

Our MPI high school faculty, most of whom have been with us since Year 1, is undergoing a change of the guard. Last year, you may recall, Calvin Nelson of Northeast High School, one of our well-liked physics

teachers, retired (and has been making adventuresome trips to places such as Alaska, and Rome, Italy, since then.) To replace him teaching physics, last August we hired Jim Graczyk from Van Horn High School, a former engineer.

Meanwhile, for two years Al Morse of Wm. Chrisman High School has been eligible to retire, but thankfully has not deprived us of his talent and dedication to teaching calculus. But we realise that sooner or later we'll have to adjust to his departure, and we dread the day.

Now this May, calculus teacher Joe Kaifes from Van Horn High School is retiring (to have his adventures on the golf course!) So, on April 4-5 we'll be interviewing 5 high school teachers, 3 from Van Horn, and 1 each from East and Northeast High Schools for a calculus teaching position. The interviews will be conducted by the MPI Director, the MPI Mathematics Coordinator, and Earl Jones of the Kansas City MO School District. Whoever is hired will join us in the adoption of a new calculus text: **Calculus: Graphical, Numerical, Algebraic**, (1994), by Finney, Thomas, Demana, and Waits, which carefully integrates the use of graphing tools into 'calculus for a new century'. We are excited to begin.

MATHEMATICS TECHNOLOGY REPORT

1. On Mar. 14, we gave a graphics calculator survey to all MPI students. We learned that of those 49 who rented the SHARP EL-9300C from us, possibly 25 plan to buy the calculator, and that over the course of a year, one change of batteries is necessary. (We may keep a small stock of batteries on hand for renters.) Here is a sample of student comments:

"General Remarks:"

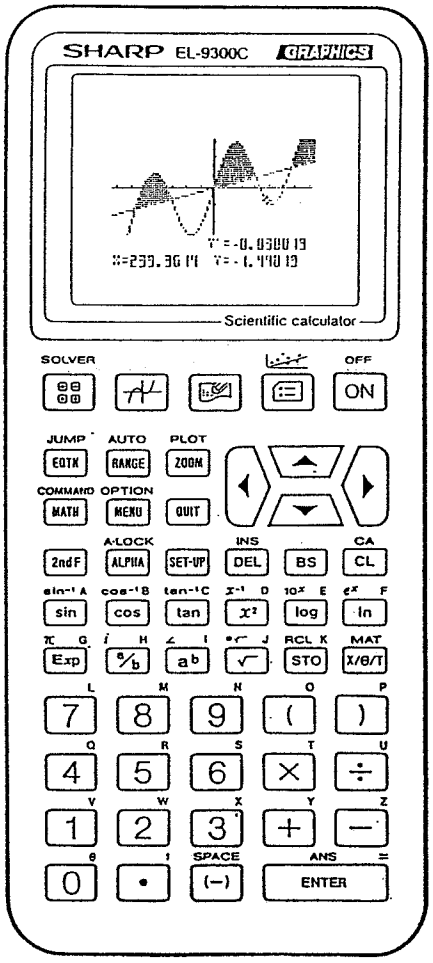
-- At first it was complicated, but after reading the calculator manual, it's really not hard to use. I'm used to it now. I feel very comfortable with it.

-- You can type in your equation like you have it written on your paper.

-- I love being able to edit my equations.

-- I like the solver most of all, even though all the features are great.

-- I like the way you can do integrals and differentiation.



"In what places and at what times do you use your calculator?"

-- MPI, home, other classes in the daytime, and at night.

-- I have grown so accustomed to this calculator that I find myself using it each time I need to compute something. Even small calculations. I use it at home, in school, in my classrooms in high school.

-- I use it all the time in trig. class, in electronics, I just use it all the time.

-- I use it in class, at work, and at home doing homework.

-- Physics and calculus, when I help people with Anal. Geo., Algebra II

etc., figuring grades (I'm a teachers' aid), at Math Relays (I placed in the top 10 in the graphing calculator category).

-- When I am graphing things during a lecture or during homework and tests.

"How do you use it in Calculus?"

-- When I'm forced to graph something on it for a calculus test. Also, to check if my answers are realistic.

-- I graph functions when I'm working on integrals to find area and volume. The picture will give me an idea of which way to lay the rectangles to be more accurate.

-- To get the picture of an equation in my head.

-- To see what the pictures look like in relationship to each other.

-- I use this to get a picture of what a graph looks like, or to see if my answers make sense by using the crosshair.

-- I'm able to see the solutions many times by just looking at the graphs.

-- I've used it to give a visual idea of what a function does. It helps to drill an idea into my brain.

-- When you graph a function you can tell what its derivative should look like so you can check work.

"How do you use it in Physics?"

-- Solver is used to store physics formulas. Many formulas in physics are used over and over again. It's nice that I don't have to keep hitting the same keys repetitiously.

-- I'm able to store equations, 99 to be exact, whether I actually use the calculation to do the work or not. Usually I do the work myself.

-- Mostly for physics tests, useful for definitions.

-- In general computation. Hail the backspace key!

-- When you get to your solution instead of taking 6 steps to simplify it you can plug it in exactly like it is and simplify it. It's nice that you can plug in an equation exactly how it is no matter how long it is because it doesn't leave room for rounding errors in your estimates.

-- It memorizes equations so as long as I understand concepts and how and when the equations work I don't have to stress over whether it was + or - or other petty things.

-- The ability to recall the exact formula needed without deriving from memorized equations is a time solver for someone who has a good understanding of the problems.

"Your recommendations to us:"

-- The day we spent in class was helpful; so was playing with it to see what it could do.

-- Be sure to explain all of the different graphing functions. Possibly spend more days letting the students get acquainted with the calculator.

-- For both classes, but especially calculus-you should give a handout with a list of things the calculator can be used for.

-- Hold that session again where you showed how to use the calculator because it was very beneficial.

-- I think it's up to the individual to use their resources. Keep showing them how to use it to begin the year and let them find how it best serves them.

-- Just explain about degree and radian modes, a lot of people messed up with that.

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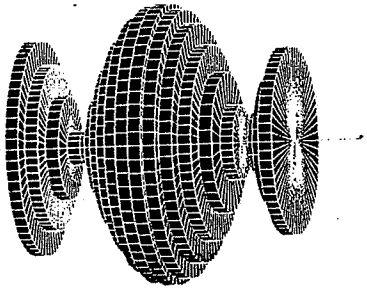
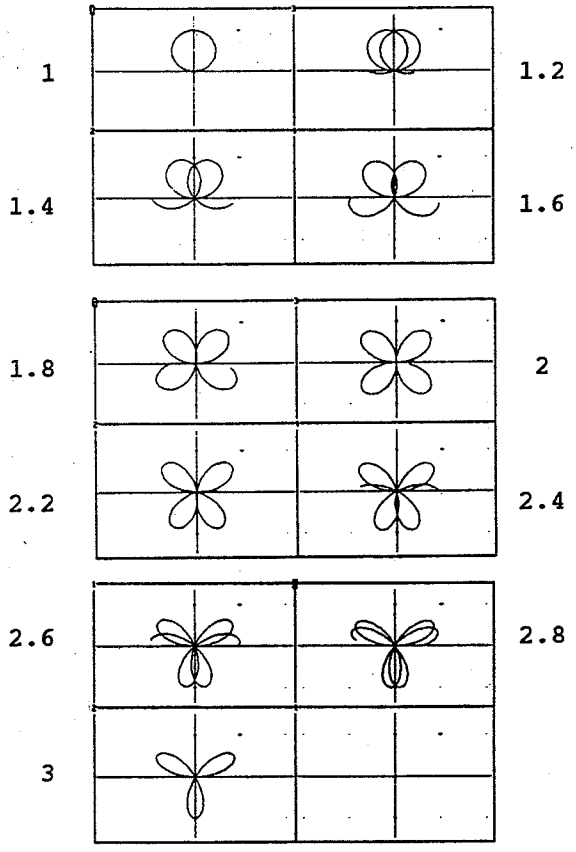
2. Most recently we used our color LCD projection panel in calculus to show animations of solids of revolution, and their disk approximations revolved about the x-axis, using Microcalc. For instance, using 19 disks to approximate the volume generated by revolving the graph of $y = \sin x$ about the x-axis from $x = -1$ to $x = 4$ produces the figure below:

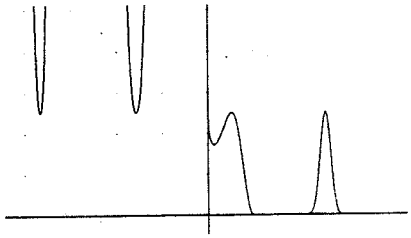


3. Two recent computer labs, **Area Between Two Curves**, and, **Some Area Properties of Cubic Curves**, generated quite a bit of enjoyment and lively lab conversation among our students. Not only did they thoroughly explore the integral notion of area, but had fun producing graphs and discussing the ideas with their partners, or seeing analytically how an area theorem for cubics is really true.

Meanwhile in Calculus II we explored polar coordinates. For example, we studied how a rose of 1 petal becomes a rose of 4 petals, and then continues to become one of 3 petals, by plotting separately the polar graphs of the roses $\sin(a\theta)$, letting "a" vary from 1 to 3, in increments of .2, yielding $\sin(\theta)$ (1 petal), ..., $\sin(2\theta)$ (4 petals), ..., $\sin(3\theta)$ (3 petals), as shown below (the "a" values are marked.):



Back in rectangular coordinates, we also probed the strange exponential function $(\sin x)^x$:



TO ALL MPI ALUMNI:

HAVE YOU GRADUATED FROM COLLEGE?

IF SO:
PLEASE CONSIDER BEING AN MPI **ENRICHMENT SPEAKER!**

CALL (816) 235-1272

VISITS, A COPIER!, AND RECRUITMENT DAY 1994

On **Feb. 10**, two reporters from **PERSPECTIVES**, the newsmagazine of UMKC, interviewed MPI faculty and students at length for a feature article in the upcoming Summer 1994 issue.

On our Recruitment Day, **Feb. 15**, we hosted 153 high school juniors and 6 teachers and counselors. The visit began with a tour of the MPI rooms, and ended with a presentation by the Director, the Mathematics Coordinator, and several current MPI students. In particular this year, after our usual slide show, we demonstrated the SHARP EL-9300C graphics calculator, using an overhead projection device, as well as both Calculus and Physics computer software projected onto a large screen by our color LCD projection panel. All our guests received a copy of the Feb. Mπ Newsletter, an MPI brochure, and a <u>new</u> sheet containing information about the Calculus Readiness Test, various MPI-recommended graphics calculators, and Derive (which is now available for a mere $89.00!).

On **Feb. 22**, after 7 weeks of class without a copier (an awkward eternity

in this business), we finally received one of our own, a Canon NP 2120, replacing the one spirited away by Engineering during their January move.

On **Mar. 17**, a photographer from the Independence Examiner visited, to take pictures for a front page newspaper article about the MPI, headlined "Experimental Program is a Success," which appeared on Mar. 22. Two students and Al Morse were photographed in a calculus problem-solving session.

THE AUGUST 1994 ISSUE

The August 1 Mπ Newsletter will list the top ten MPI students for 93-94 and all those receiving awards at our May 19 Awards Presentation.

There will also be IMPORTANT INFORMATION and advice for the YEAR 11 class of 94-95. TAKE NOTE!

ENRICHMENTS

FOLLOW UP

On Feb. 11, for his first time, UMKC physicist Michael Kruger addressed the exploration of high pressure physics using diamond anvil cells in his talk **JOURNEY TO THE CENTER OF THE EARTH.** Some student comments were:

--He talked about his work with the diamond anvil cells and his attempt to make a useable amount of a substance that is harder than diamonds.

--He talked about how pressure affected different substances. He showed us the technological advances due to pressure research.

--He works a lot on the diamond anvil cell. This device uses real diamonds to reach high pressures. Pressures close to those at the center of the earth have been reached.

--He talked about high pressure and how it could be achieved using small areas and not huge, brute force.

--In his experiment Dr. Kruger used the hardest substance, two diamonds, at each end [of the cell] and a ruby in the middle. The ruby serves as the measure of how high the pressure is when the two diamonds are pressed together.

On Feb. 25, in lieu of a "live" speaker we showed a video of one of our former speakers, Wai-Yim Ching, a theoretical condensed-matter physicist and chairman of the UMKC Physics Dept., entitled **AN INTRODUCTION TO HIGH TEMPERATURE SUPERCONDUCTIVITY.** Although it was clear that our students prefer "live" speakers, some comments were:

--Superconductors are materials whose resistivity drops suddenly to zero at very low temperatures. They offer no resistance to electric current.

--His visual outlines were very helpful especially because of his accent. At times he was difficult to understand, but the outline clarified any of my confusion. The "special effects" on the video were neat. The demonstration at the end was interesting too. It was just like a classroom lecture. I enjoy things that are up-and-coming, and ongoing experiments that may have an impact on me.

--I found it interesting that the mysteries of superconductivity stupefied even Einstein and Bohr.

--The speaker made superconductors appear to be the best thing since sliced bread. Although his style was a bit dull, he was very knowledgeable in this area and well prepared to give this presentation. Except for losing the hands-on part of presentations, I would suggest trying to get people who can't come over to the MPI to make video presentations such as this.

On Mar. 11, Lori Hill, a former MPI physics tutor, now a Senior Software Engineer at Wilcox Electric, Inc., spoke on **LANDING PLANES USING SATELLITES: THE GLOBAL POSITIONING SYSTEM.** Students enjoyed the talk, which included an in-the-cockpit video of a plane landing entirely by the GPS system. They responded:

--She began by telling briefly how planes are landed in the present. She then moved into the possible future use of the global positioning system for not only landing planes, but as maps in cars and hand-held

maps too. I liked the video, it brought GPS to life. I enjoyed this enrichment very much. She included just enough information to be interesting but not to confuse.

--The GPS is currently used commercially and by the military to locate the exact location of objects anywhere in the world (at an accuracy of ± 40 ft.). As this technology becomes less expensive and more compact the benefits gained by backpackers, hikers, and boaters etc., will be well worth the cost.

--Ms. Hill mentioned many applications for GPS including maps in cars. She dealt a little with security and built-in error and control that DOD has over the satellites. However, she didn't mention the possibility of space debris diminishing satellite capability or what would happen if we became over-reliant on GPS, and an electro-magnetic pulse destroyed all satellite transmission for GPS.

--In November the first [GPS] system will be used in a commercial plane, in Europe.

--Since mechanicals are actually landing the plane instead of a person the landing is dead on, smoother, and safer. A video of a GPS provided proof for her talk. Very interesting!!

--This was one of the best speakers we've had yet! She was articulate and presented her material with knowledge and enthusiasm.

--One other thing I found interesting was the fact that one day the [GPS] locators will be in cars, and when you want to find out where the gas stations are, you'll just punch it in and it'll show you.

On Mar. 25 Tony Hancock, a British chemist and science administrator at Marion, Merrell, Dow, Inc., spoke on **MOLECULAR ARCHITECTURE.** [Due to our MPI Spring Break, student comments on his talk won't appear until the August Mπ Newsletter.]

UPCOMING

On April 15, Brent Harding (MPI 84-85), now an aerospace engineer at McDonnell-Douglas Aerospace, Space and Defense Systems, Houston Division, will return for the third time as a speaker, to discuss **HUBBLE REPAIR, ASTEROID MISSIONS, AND A COMET STRIKE ON JUPITER.**

We haven't yet confirmed a speaker for April 29.

Sun. May 8, Mother's Day, will be our annual **WORLDS OF FUN PHYSICS DAY.**

We have not yet confirmed a speaker for May 13, but Shelley Wolff, a civil engineer, will likely discuss **HIGHWAY SLOPE DESIGN.**

Finally, we'll hold our annual **PICNIC/BREAKFAST** at McCoy Park on May 18, and our **AWARDS PRESENTATION** on May 19, the last day of the first decade of the MPI!

WE HEAR FROM PAST STUDENTS

SHALOM BARBER (90-91)
(Pre-Medicine Major)

"I have only taken one math course, General Statistics, which was too easy, and I have not taken my other semester of physics yet. I do feel though that the classes have helped me through my chemistry courses, and through many others. They helped prepare me for college, I didn't have to adjust like others as a freshman. And the difficulty of it wasn't exactly hard, but intense enough to make me study and to help prepare for the many other courses I've taken."

MALISSA SHROUT (89-90)
(Not now in school.)

"MPI was much more people oriented. The math classes I've had since have all been either "figure it out on your own" or "find a tutor." The instructor never seemed to have time to help.

[The MPI] made me more aware of how college would be before I went, therefore I had less anxiety about starting.

Keep up the good work. I'm glad to say I participated in the MPI program."

AMANDA KOSTER (92-93)
(Biology Major)

"There's no way I would have gotten A's in biology and chemistry if I hadn't learned the importance of study groups while at the MPI. (Also, standing up for 3 hours in my chemistry lab wasn't as hard as I thought it would be, thanks to my physics lab experience.)

Through the MPI, I learned the futility of trying to continue studying once you get really frustrated and the need to take a break and return to the studying later. I also learned that getting a good test score takes more than one night's studying.

I don't know how much of it was the MPI and how much was my overall senior year experience, but I have a lot more confidence facing both the new people in my classes and the challenging course material.

To be quite honest, aside from having great teachers (something I appreciate more now), the variety of possibilities shown through the enrichment program are the strongest and most enlightening images and ideas I have from the MPI.

If there is anything at all, I got too dependent on having collected homework assignments. Keeping up when it's not being collected takes a bit of self-motivation.

Nothing can give you a taste of college like the MPI can.

I am so glad I went to the MPI. It was a wonderful, original experience. I've compared it with other programs my college friends from other places have taken, and I have every reason to be proud and glad that I got to experience something as unique and fun as the MPI. Thanks for the opportunity!"

LESLIE (FARROW) BAY (91-92)
(Accounting Major)

"Calculus and physics at MPI were very well taught. I am constantly thinking about how much they prepared me for college classes. At MPI I understood the concepts and if I didn't there was always someone there that could explain it to me. I'm very grateful for having an MPI at my high school. I would be totally lost at college if I hadn't taken those courses.

MPI gave me a head start over other entering college freshmen. Finishing MPI gave me courage to tackle more demanding classes than the required classes.

I believe MPI has had an effect on how successful my life has become. MPI helped me to learn responsibility, how to budget my time and interaction with people. I am very proud to say that at age 19 I am completing my second year of college, while working full-time, plus spending enough quality time with my husband, and fixing up our house we just purchased."

DESMOND McGUIRE (91-92)
(Civil Engineering Major)

"When I attended MPI I did not have trigonometry and my algebra skills were not as high as they should have been. At UMKC I took an algebra/trig. class. After I took that class I was well prepared for calculus. MPI is why I am majoring in Civil Engineering. Although I did not excel while I attended MPI, I knew math and physics would be my strength after I applied myself and got my skills caught up to where they should be."

TINA JENKINS (89-90)
(Biology Major)

"The instruction I received at MPI was of high quality, much better than the instruction I have received at UMKC.

My MPI experience has taught me the importance of focusing and applying myself in school."

SETH McMENEMY (88-89)
(BS Electrical Engineering)

"I am currently gaining that 'real-world' experience, and learning a lot. I plan to go back to school soon either as an MBA, or Engineering Masters or Both.

I want to encourage everyone to look for opportunities to start, drive, or actively participate in programs, organizations, clubs, etc. If you want to start a mountain bike club, start one. If you want to join the "United We Stand" movement, do it. Being a part of these types of organizations is where you find what you want to do.

I also recommend tutoring. It's a good way to help others while you are learning a subject better. In fact, someone ought to go after some state (or local) money to start a "Learning Center" at the MPI and in the respective school districts. Tutoring is very beneficial to everyone involved.

I know MPI has an e-mail address... Maybe MPI can set up a computer "Pen Pal" program to connect current students w/MPI alumni.

Give me a call if you would like to talk about any of these suggestions."

SHELLY CARTER (92-93)
(Business Administration Major)

"It was great. I can't think of the best reason but I enjoyed the responsibility that was given to us as if we were real college students. This made me realize that I was the only one who could make myself do the work."

MORE 93-94 STUDENT IMPRESSIONS

"MPI has been a great experience for me because it has taught me more than merely physics and calculus. It has taught me to be responsible and productive with my time. I enjoy being here even though calculus is probably the last thing anyone would want to think about at 7 am."

Hanh Phan
Northeast High School
Kansas City School District

"I believe calculus and physics at MPI have been the most beneficial courses I have taken during my high school career. They have increased my analytic and logic thinking skills noticeably. I can imagine no greater preparation for college than to be thrown in with exceptional teachers and the best competition in the area.

What makes the MPI experience most valuable is the special closeness that has formed in our sections. We've learned the strong strengths and weak characteristics of each other and have molded them together to form one big pulsing brain, computing integrals and deciphering temperatures, and also having a lot of fun."

Bobbi Jo Hopkins
Wm. Chrisman High School
Independence School District

"MPI prepares you for college and gives you a GOOD IDEA of what it will take to survive in classes. It teaches you to become more responsible and make personal sacrifices. I've made some decisions this year that I would have never made before I started these classes and I've become much more independent which will really help me next year when I go away to college."

Jessica Schmitt
St. Mary's High School
Ft. Osage School District

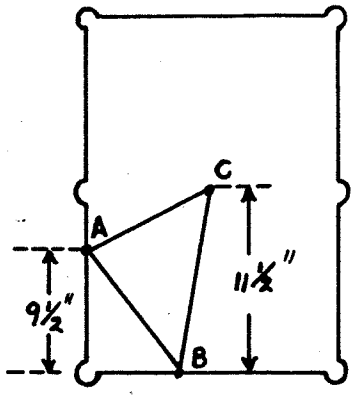
"MPI has been an excellent learning experience. I have recommended MPI to many of my junior friends. The experience gained at MPI has been very beneficial to my preparation for college."

Mike White
Ft. Osage High School
Ft. Osage School District

A SOLUTION TO MATHEMATICS CHALLENGE #32

Recall the problem statement:

Suppose the (equilateral) triangle used to rack the balls for a game of pool is lying on the pool table as shown, where the measurements are given in inches:



How far is the point B from the nearest (lower left) pocket?

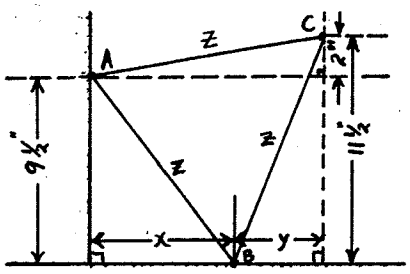
[From: Ingenious Mathematical Problems and Methods, by L.A. Graham]

SOLUTION:

We'll examine 5 solutions of this simple problem. All measurements are in inches:

1. PYTHAGOREAN THEOREM & ALGEBRA

Dropping perpendiculars to create the 3 right triangles in the figure below,



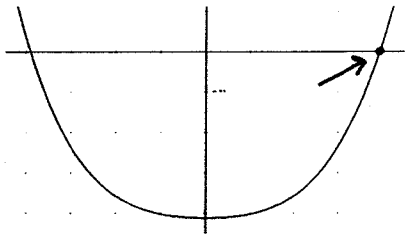
and using the Pythagorean Theorem, we get 3 equations which we want to solve together for x:

(Lefthand Δ) $x^2 + 9.5^2 = z^2$
(Righthand Δ) $y^2 + 11.5^2 = z^2$
(Upper Δ) $(x+y)^2 + 2^2 = z^2$

Combining these (you're welcome to slog through the algebra!) leads inevitably to:

$$3x^4 + 88.5x^2 - 16{,}488.0625 = 0.$$

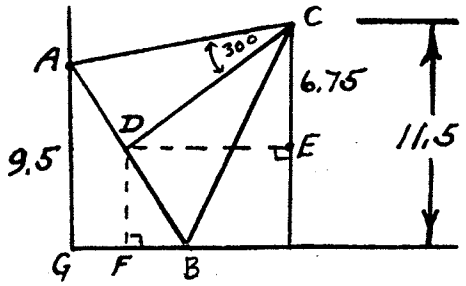
Using Derive, we find one positive real root both graphically and algebraically:



$$\sqrt{\frac{\sqrt{205689}}{6} - \frac{59}{4}} \approx 7.79988.$$

2. SIMILAR TRIANGLES

In the figure below, D is the center of side AB, so CD is perpendicular to AB, and CED and AGB are similar triangles, since their sides are respectively perpendicular:



Hence we have $\frac{BG}{AB} = \frac{CE}{CD}$. But, remembering that triangle ABC is equilateral, with equal 60° angles, and CD bisects one of these angles, we have

$CD = AC \cos 30° = AB \cos 30° = AB\sqrt{3}/2.$

Also, since D bisects AB, then DF = (9.5)/2 = 4.75, meaning

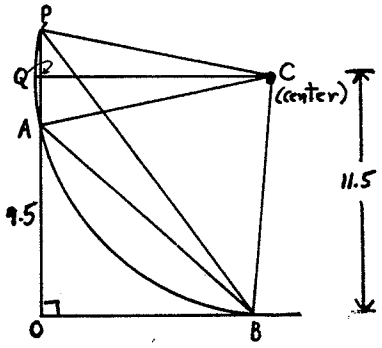
$CE = 11.5 - 4.75 = 6.75.$

So, $\frac{BG}{AB} = \frac{CE}{CD} = \frac{6.75}{AB\sqrt{3}/2}$, meaning

$BG = (6.75)(2/\sqrt{3}) = (13.5)/\sqrt{3} \approx 7.79422.$

3. SUBTENDED ARCS

Draw a circle with center C, passing through B. It will then pass through A (of course), and a new point P, as shown below:



By construction, ΔCAP is isosceles, so CQ both bisects PA and is perpendicular to it, meaning PQ = AQ = 11.5 - 9.5 = 2, and OP = OA + AQ + QP = 9.5 + 2 + 2 = 13.5. Since the (central) angle ACB = 60°, so that

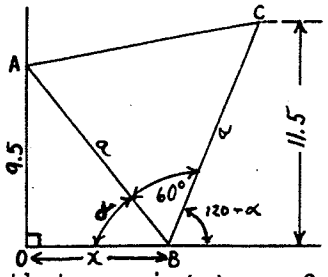
arc AB = 60°, and since point P lies on the circle, it follows from elementary geometry that angle BPA = (1/2)60° = 30°. Thus ΔOPB is 30-60-90, meaning PB = 2(OB), and by the Pythagorean Theorem,

$$[2(OB)]^2 = (OB)^2 + (OP)^2$$
$$4(OB)^2 = (OB)^2 + (13.5)^2$$
$$3(OB)^2 = (13.5)^2$$
$$OB = 13.5/\sqrt{3} \sim 7.79422,$$

exactly as in solution 2 above.

4. TRIGONOMETRY

From the figure below,



we see that $a\cdot\sin(\alpha) = 9.5$, and $a\cdot\cos(\alpha) = x$, and since for angles $\leq 180°$, sin(angle) = sin(180°-angle),

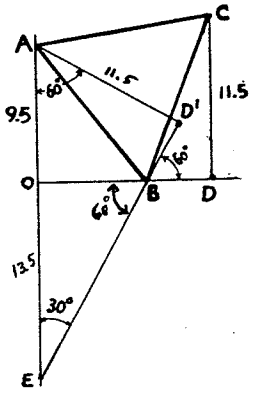
$$\begin{aligned} 11.5 &= a\cdot\sin(120°-\alpha) \\ &= a\cdot\sin(180° - (120°-\alpha)) \\ &= a\cdot\sin(\alpha+60°) \\ &= a[\sin(\alpha)\cos(60°) + \cos(\alpha)\sin(60°)] \\ &= 9.5(1/2) + x(\sqrt{3}/2). \end{aligned}$$

Thus, $x = (2/\sqrt{3})(11.5 - 4.75) = (13.5)/\sqrt{3} \sim 7.79422$, once more.

[A variation of this solution was submitted by MPI alumnus Phuc Do (85-86).]

5. CLEVER TRIGONOMETRY

To construct the figure below, drop the perpendicular CD as shown, and swing side BC counterclockwise about the vertex B until it coincides with AB. So, CD swings into the new position AD', and DB swings into D'B, meaning angle DBD' must be 60°, and AD' = CD = 11.5. Extend D'B to E as shown:



By inspecting this figure we see that angle EBO (vertical to angle DBD') is also 60°, forcing OEB to be 30°, so that angle EAD' is 60°, meaning ΔAED' is 30-60-90. So, side AE = 2(AD') = 2(11.5) = 23, forcing OE = 23 - 9.5 = 13.5, hence finally:

$$OB = (13.5)\tan(30°) = (13.5)/\sqrt{3} \sim 7.79422, \text{ again.}$$

A SOLUTION TO PHYSICS CHALLENGE #23

Recall the problem statement:

SNOW CATCHER

A woman skiing across a field with a speed of v = 20 km/hour in a heavy snowfall observed that her mouth encountered N_1 = 50 snowflakes per minute. After turning back across the field, she noticed that only N_2 = 30 snowflakes hit her mouth per minute when skiing with the same speed. (A very observant woman indeed!) She also noticed that the wind velocity in her original direction was a constant w km/hour. [Assume S = 24 cm^2 is the area of the her mouth in the direction of travel.]

Estimate the Visibility during this time, where "Visibility" can be estimated as the average length L of a cylinder with cross-sectional area A equal to the area of 1 snowflake. [Assume that the average diameter of a snowflake is d = 1 cm.]

[From: M. Semyonov, Quantum Magazine, Nov/Dec 1993]

SOLUTION:

Suppose a unit volume of air in meters^3 (m^3) contains p snowflakes. Then, using the notation and definitions from the statement of the challenge above, and converting all units to meters and minutes, we have:

In her **original** direction of travel:

$$\begin{aligned} N_1 &= pS(v + w) \\ &= p(S/100^2)(1000(v+w))/60 \\ &= p(24/100^2)(1000(20+w))/60 \\ &= p(20+w)/25 \end{aligned}$$

where the units are

(flakes/min.) = (flakes/m^3)(cm^2)(km/hr)

= (flakes/m^3)($m^2/100^2$)(1000m/60min.).

Likewise, in the **opposite** direction:

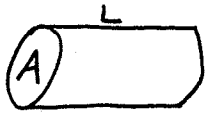
$N_2 = p(20-w)/25$.

So, from $N_1 + N_2 = p(40)/25 = 8p/5$, we get

$p = 5(N_1 + N_2)/8 = 5(50+30)/8$
$= 50$ (flakes/m^3).

Now, the volume of the cylinder of air containing only 1 snowflake, which we'll use to estimate visibility, is LA, where L is the maximum possible length of such a cylinder, and A is its cross-sectional area:

$A = \pi(\text{radius}^2) = \pi(d/2)^2 = \pi/4$ cm^2.



So, since (flakes) = (m^3)(flakes/m^3),
$1 = (LA)p = L(A/100^2)p$
$= L(\pi/40000)(50) = \pi L/800$, meaning
$L = 800/\pi \approx 254.64$ meters visibility.

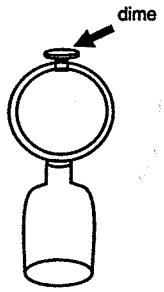
MATHEMATICS CHALLENGE #33

A city has 10 bus routes. Is it possible to arrange the routes and the bus stops so that if only ONE route is closed, it is still possible to get from any one stop to any other (possibly changing busses along the way), but if any TWO routes are closed, then there are at least 2 stops for which it is <u>impossible</u> to get from one to the other?

[From: Challenging Mathematical Problems with Elementary Solutions, Vol.II, by Yaglom & Yaglom.]

PHYSICS CHALLENGE #24

Balance a wooden embroidery hoop on the top of an empty bottle whose opening is larger than a dime. Place the dime on the hoop as shown.



How can you knock the hoop away with your finger so that the dime falls into the bottle?

[From: The Physics Teacher, Feb. '94]

Editor/Writer: Richard Delaware

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