WELCOME TO YEAR 18

We welcome the 18th class to the MPI, representing 9 high schools: Central, Center Place Restoration, Englewood Christian Academy, Fort Osage, Northeast, Paseo, Southeast, Truman, and William Chrisman.

MPI STUDENT ORIENTATION
August 29-31, 2001

Each year the first three days at the MPI are spent in giving our students an overview of how we operate, a discussion of our policies on attendance, grading, etc., and two diagnostic tests. Time is then set aside for the instructors to informally ‘get to know’ their classes before we all become preoccupied with class work.

In particular, on the first day, August 29, 2001, we’ll provide each student with a packet of information and have each of them fill out a personal data form.

If you have any questions, call our MPI secretary, Donna, Mon-Thurs., 8:00am to 1:00pm, at 235-1272. We look forward to seeing our 18th class on Wed., Aug. 29, at 7:00am in Room 207!

STUDENTS PLEASE BRING:
ON AUG 29, 7am, TO ROOM 207

• Your Social Security Number.
• $10.00 to rent a calculator.
• Your daily schedule of high school classes.
• Your schedule of extra-curricular activities.
• Your counselor’s name.
• Ideas for Enrichment Speakers or topics.

MPI GRAPHICS CALCULATORS

The MPI requires ALL students to have and use a graphics calculator in both physics and calculus. For our purposes we have selected the SHARP EL-9600. Although the SHARP is not the most powerful graphics calculator on the market, it is ideally suited to the MPI and its selection of students. One unique feature, even in older models, is the ability to enter fractions and exponentials exactly as you would write them on paper. Some features are:

- Pen-touch screen entry option.
  [A plastic stylus is included.]
- TABLE feature.
- Unique Rapid Graph, Rapid Window, and Rapid Zoom features.
- Connects to a TI CBL (Calculator Based Lab).
- Split Screen option.
- More pixels for a finer screen resolution.
- Slide show feature.

All MPI students are required to EITHER rent a SHARP EL-9600 from us, paying a $10.00 one-time non-refundable fee for the entire academic year, with an option to buy the calculator outright at any time [the full price, after the rental fee is deducted, is $60.00], OR, to provide themselves with an equal or better graphics calculator except for the TI-89, TI-92, and other calculators with computer algebra systems included. Please note that MPI support and an MPI calculator manual will only be provided for the one calculator we rent.

The MPI-rented calculators will initially be loaded with a set of AAA batteries, but as these fail over the course of the year, student-renters are entirely responsible for buying and replacing them. (Our experience has been that at most one or two replacements are needed over the year.)
TO ALL MPI ALUMNI:

HAVE YOU GRADUATED FROM COLLEGE?

IF SO:
PLEASE CONSIDER BEING AN ENRICHMENT SPEAKER—
CALL 816-235-1272
Or contact us at 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)

CALCULUS I & II

<table>
<thead>
<tr>
<th>NAME</th>
<th>SCHOOL</th>
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<tbody>
<tr>
<td>Mike Bowerman</td>
<td>Ft. Osage</td>
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<tr>
<td>Chris Gordon</td>
<td>St. Mary's</td>
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<td>Emal Latifzai</td>
<td>William Chrisman</td>
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CALCULUS II

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<tr>
<td>Kevin Tisdale</td>
<td>Blue Springs</td>
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PHYSICS

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<td>Luke</td>
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2001 MPI AWARDS PRESENTATION
AND TOP 10 MPI STUDENTS OF 2000-2001

Our final awards presentation was held on May 10, 2001, during which we were pleased to present many of our students with the following variety of awards. Also present were administrators for Independence: David Rock, Superintendent and Cliff Mohn, Assistant Superintendent; Mrs. Hawa Latifzai, parent of Emal Latifzai, Steve Scott, principal of Fort Osage High School, Mike Jeffers, Vice Principal of Truman High School, Dave Sharp, Assistant Principal of William Chrisman, John Rounds, Counselor for William Chrisman High School, and Archie Gatrost, teacher at CPRS.

CALCULUS I

<table>
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<th>NAME</th>
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<td>Aaron</td>
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<td>Josh</td>
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<td>Kevin</td>
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We also honored the TOP TEN students (ranked according to the mean of their full-year college calculus and physics grades) by giving them a one year subscription to Scientific American Magazine and a copy of "What's Happening in the Mathematical Sciences."

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<thead>
<tr>
<th>RANK</th>
<th>NAME</th>
<th>SCHOOL</th>
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<tbody>
<tr>
<td>1</td>
<td>Emal Latifzai</td>
<td>Wm Chrisman</td>
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<td>2</td>
<td>Jamie Chapman</td>
<td>Truman</td>
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<td>3</td>
<td>Aaron Ballantyne</td>
<td>CPRS</td>
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<td>4</td>
<td>Mike Bowerman</td>
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<td>5</td>
<td>Wyeth Killip</td>
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<td>6</td>
<td>Josh Bergsten</td>
<td>Truman</td>
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<td>7</td>
<td>Chris Gordon</td>
<td>St. Mary's</td>
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<td>8</td>
<td>Allison Scott</td>
<td>CPRS</td>
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<td>9</td>
<td>Luke Whorton</td>
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<tr>
<td>10</td>
<td>Megan Roney</td>
<td>Truman</td>
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</table>
Finally, we list those MPI students planning to attend UMKC who received various scholarships from UMKC; included are those students to whom the MPI awarded Chancellor's Scholarships:

**UMKC Chancellor's Award Winners:**

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Scholarship</th>
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<tr>
<td>Mike Bowerman</td>
<td>Ft. Osage</td>
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<tr>
<td>Stephanie Kelley</td>
<td>Wm. Chrisman</td>
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**UM Curators Award Winners:**

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<th>Student Name</th>
<th>Scholarship</th>
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<td>Aaron Ballantyne</td>
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<td>Christopher &quot;Kit&quot; Dawson</td>
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<td>Lindsey Kleyh</td>
<td>Wm. Chrisman</td>
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<td>Chris Moore</td>
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<td>Megan Roney</td>
<td>Truman</td>
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<tr>
<td>David Smith</td>
<td>Truman</td>
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<tr>
<td>John Waldman</td>
<td>Ft. Osage</td>
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**ADVICE TO STUDENTS OF YEAR 18 FROM THE STUDENTS OF YEAR 17**

At the end of this last year, in May, we decided once again to have our students write whatever they wanted in answer to the question:

“What ADVICE would you give to incoming students about study, attitude, or any other aspect of surviving the MPI in 2001-2002?”

We were pleased at how seriously and with what maturity they wrote, and so each incoming student will receive a complete set of these words of advice from the students of Year 17. Here are some excerpts from that document.

"Study constantly, and always do every assignment – NEVER think you can afford to miss one, or be able to turn it in late. That kind of attitude is a surefire way to destroy even the highest grade. Also, always get to MPI on time – thinking you can afford being five minutes late will lead to being ten minutes late, then twenty…and doing that when you have an exam in your first class is NOT good. Missing twenty minutes of lecture on a new topic doesn’t help either.”

  Jared Allen  
  Truman High School

"I know that it doesn’t matter what I say because you already think that you know everything, you already think that if we didn’t do well here it is because we were stupid. I can assure you that this is not the case. MPI has broken some of the smartest people to ever grace the earth. MPI has also had some of the mediocre people rise to the top and succeed. What I say now doesn’t matter because you won’t listen, but on the off chance that you are listening, you should pick a partner and start studying every night. If you don’t, you will start to fall behind and the longer you wait, the harder it will be to catch up. Other than that all I can say is don’t forget to have fun - it’s your Senior year.”

  Kevin Canning  
  Ft. Osage High School

"When you come to MPI, study a lot. It will benefit you. When they give you homework or suggested problems, do most of them. They give you experience and let you get ready for anything that they give you on the tests. They give a lot of tests so improve your test-taking skills. Also, ask a lot of questions, remember the stupidest question is the one not asked. MPI was fun for me because it prepared me by showing a little what it is like in college. It also gives you the opportunity to meet other people from other schools which is a lot of fun.”

  Nehemiah Hanson  
  Ft. Osage High School

"The most important thing to do is complete all of the homework, even if it is only suggested. I promise, you will be glad you did come test day. Second, find a friend to study with in both classes. This person will help to motivate you as you help with them. Good to every study session you can if you do not understand the subject matter. The teachers are here to help. At the beginning of the year, the stuff the teachers tell you will probably sound scary, but do not worry. The MPI is not that bad. It is a great experience. Enjoy it and do not stress about it too much. It is a great experience, and you will be prepared for college. Stick in there and don’t let yourself get too far behind.”

  Jamie Chapman  
  Truman High School

"Make sure you start the year by working hard. You need to understand the beginning for the end. Also, this ensures that as your effort inevitably declines, you still have enough left to end up with a decent grade.

  Also, don’t try to do everything at the same time. Make sure you cut down enough so you can get enough sleep to stay awake during tests.”

  Chris Gordon  
  St. Mary’s High School
"In the beginning there is study. After a while there is slacking, and by the end you are working to make up for what was missed. When MPI first started, I read the manual & everything that the class before us said, but I still didn’t listen. Remember to study for each exam by doing the suggested problems. You will do a lot better on exams if you study."

Stephanie Kelley
William Chrisman High School

“When you come to the MPI, come thinking you will have to put forth more effort than you ever have before, because if you expect to pass, you will have to. It takes studying, which for Ft. Osage students like myself, is somewhat of an enigma. I was completely unprepared for the MPI calculus. Physics wasn’t so bad. I was near failing several times this year, and I have never had a grade lower than a “B” before this year. Although, with everything that I fought through, the MPI is not impossible. If you stay dedicated, unlike me, you will succeed in this environment.”

John Waldman
Ft. Osage High School

“For my opinion, you all have to come to class on time, pay attention in class, try to finish all the suggested homework for calculus, and all assignments that teachers hand out. You have to review well for tests. Spend time for homework, at least 1-2 hours. Try to keep it up and do not drop out because you know that you can do it.”

Loc Nguyen
Northeast High School

“Be honest with yourself when deciding what workload and academic expectation you can bear! Recognize that this course demands much much more than any other course offered at your high school. Become good friends with someone who you can study with. You will not survive alone! Recognize what your expectation of the course is. Be organized and on time!

Don’t doubt yourself. This course is 75% confidence, 25% knowledge. I am serious. Everyone can do well, it just depends how well you think you know the information from the get go - the information is all encompassing.

Get adequate sleep! Get adequate sleep!

Get adequate sleep!

Realize that you cannot do it all and by prioritizing you will see what activities and opportunities make you most happy!

If you think MPI is going to be too hard, just know that there is always candy on the secretary’s desk. Personally I do not know how I would have survived without it. If candy is not enough incentive, then just know that quite often someone brings donuts and, boy, are they um um good!

Good luck in all that you do and drive carefully in the MPI parking lot! (There are some crazy drivers every once in a while.)

Wyeth Killip
Truman High School

“Study a lot! At the beginning of the year you do study, but towards the end it’s easy to slack off. Don’t do that if you want your grade to be good! Don’t drop out. Wait at least until second semester because if you can make it to there, the rest is much better. Have fun and don’t stress out too much.”

Allison Scott
Center Place Restoration School

“Start training before school. Wake up at the crack of dawn and climb 4,000 stairs, then watch at least 3 hours of C-Span. Do this for a month or so. When MPI actually starts, then you need to keep up. If you don’t keep up then it will all start to fall down around you. Oh yeah, DO THE CALC WORK! It’s not required but it pays off. If you keep on top of things and stay awake during lectures you should do fine.”

Adam Stickley
Truman High School

THE 2001-2002 CLASS (TO DATE)

Section A (17)

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<tr>
<th>NAME</th>
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<tr>
<td>Kristen</td>
<td>Englewood Christian Academy</td>
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<td>Tim</td>
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<td>Andrew</td>
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<td>Reva</td>
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<td>Kari</td>
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The 2001-2002 Staff

In Physics:

Larry Harding (retired), from Fort Osage High School and Russell Clothier, a new Truman High School Physics teacher, with some assistance from our liaison Roy Cook of Northeast High School.

And, in Calculus:

Sheri Adams from Truman High School, and Libbi Sparks from William Chrisman High School.

Our University staff is listed in the heading of this newsletter, and our half-time secretary and assistant is Donna Dilse.

MPI T-Shirts!

Beginning in about October, we will once again be selling MPI T-shirts and sweatshirts to our students. These shirts have a classy 3D graph \((z = \cos x \sin y)\) on the back and our student-designed MPI logo on the left front.

Enrichments

Follow Up

On April 6, Tina Niemi, UMKC Geosciences, spoke on Paleoseismology and Probabilities of Future Earthquakes.

Student comments were:

- Earthquakes occur often and are dangerous. They are created by naturally created seismic waves as well as large explosions. Seismology studies these occurrences and Paleoseismology studies ancient earthquakes. It is a branch of geology. They can tell about when prehistoric earthquakes occurred and can help prevent future earthquakes. At a fault line, a slip is a sudden release of stress and creates shaking of the ground. Stress and strain are important in the physics of seismology. Stress is a force over an area. The change in shape caused is its strain. The force is a compression force.
She used a wooden block with sandpaper on the bottom and attached a rubber band, which she pulled to show the proportion of the energy to the size of a quake. There is elastic energy that is released at once in earthquakes when the plate's friction is overcome. The greater the stored energy, the greater the Richter reading.

Good enrichment. Educating and interesting. I do wish she had time to delve into probability of earthquakes and predictions.

I think it would have been cool to see more pictures of what earthquakes can do and what to do in case of an earthquake. It is very interesting the way they can find places where earthquakes happened underground a long time ago.

On April 27 Brent Harding (MPI 1984-85), Engineer Specialist with Orbital Sciences Corp., spoke on APPLICATIONS OF SATELLITE TECHNOLOGY.

Students responded:

Sun sensors, earth sensors, star trackers, magnetometers, and gyroscopes are used for attitude determination. Three satellites are used to zone in to one location. Because of atmospheric conditions, satellite signals move around continually, but satellites can locate a position within 20 to 30 feet. For satellite control, they use thrusters, reaction wheels, solar sails, and magnetic controllers. To rotate a satellite with wheels, they spin the wheel the opposite direction of the way they want to turn the satellite (like we did in Physics class). The applications of satellite technology are communications, saving the earth, tourism, remote sensing, and exploration.

The Global Positioning System was first used for the army as a military project. They did this so that other countries couldn’t use their technology to bomb us. GPS is the best and most accurate way to find a satellite. On a satellite they use magnetic controllers to let it align itself with the earth’s field. Therefore, it enables the satellite to control itself to line up with the earth.

Mr. Harding started by talking about his educational and work history. Then he talked about putting a satellite together. He then talked about Navigation, the GPS system (complete with demonstration involving slinkys), sun sensors, earth sensors, star trackers, magnetometers, gyroscopes, thrusters, reaction wheels and magnetic controls. He also talked about solar sails and their possible use for controlling satellites. He showed video clips of the Mars Oddessy Launch. He also talked about problems from some satellites.

This guy was the best one all year!

A very interesting speaker. He kept the attention of just about everyone that was there. Along with helping in terms that we were able to understand.

He was great! The subject matter was interesting, and he interacted very well. Very funny and interesting.

What a fabulous way to end the year! He was great!

UPCOMING ENRICHMENTS

One of the special features of the MPI is its biweekly enrichment series, in which on alternate Fridays either professionals in the sciences, engineering, mathematics, etc., speak to our MPI students, or, we take a field trip to such places as Linda Hall Library of Engineering, Science, and Technology, UMKC’s Physics Department, or Worlds of Fun for some ‘hands on’ physics.

As part of our early MPI orientation, of UMKC, will speak on August 31, about college admissions in general, and the importance of thinking about applications EARLY. (This is not intended to be a recruitment for UMKC, but a general discussion to help sensitize our students to the importance for colleges of deadlines.)

On September 14, Douglas Carroll from the Dept. of Basic Engineering at the University of Missouri-Rolla will speak on SOLAR CARS. He has been the advisor for the UMR Solar Car Team since 1992, and has done research on composite materials. For more information, visit his website at: http://www.umr.edu/~douge/.

We have not yet scheduled an Enrichment speaker for September 28.

The October newsletter will report on those speakers scheduled for October and beyond.

Continued after the Calendar →
Mathematics and Physics Institute

CALENDAR  2001-2002

YEAR 18

MPI Begins
1st Quarter Grade and Probation Reports Sent
MPI OPEN HOUSE for Parents/Teachers/etc.
Thanksgiving Holiday
Final Exam – Calculus I - (Math C Only)
2nd Quarter/1st Semester Grade Reports Sent
Christmas Holiday
MPI Classes Resume
PANEL DISCUSSION & REUNION
Martin Luther King Holiday
President's Day Holiday
3rd Quarter Grade Reports Sent
MPI Spring Break
MPI Classes Resume
Final Exams – Calculus I (A,B,D) and Calculus II (C Only)
Final Exam – Physics
MPI Breakfast
MPI Awards Presentation/Last Day of MPI Classes

Wed, August 29, 2001
Thurs., August 18, 2001
Sunday, November 4, 2001
November 22-23, 2001
Wed., December 19, 2001
Thurs., December 20, 2001
December 22, 2001-January 6, 2002
Mon., January 7, 2002
Tues., January 8, 2002
Mon., January 21, 2002
Mon., February 18, 2002
Thurs., March 7, 2002
Mon.-Fri., Mar 25-29, 2002
Mon., April 1, 2002
Mon., May 6, 2002
Tues., May 7, 2002
Wed., May 8, 2002
Thurs., May 9, 2002
TO THE PARENTS OF THE 2001-2002
CLASS AT MPI

This newsletter is written for YOUR
information, and there will be one sent to you every
two months during this year, while your son or
daughter is at the MPI.

We firmly believe that without your support
and concern at home, students cannot succeed in such
a rigorous program as the MPI. Our classes are NOT
high school classes and require both study skills and
a commitment that students still in high school,
however talented, have not experienced before. In
both of these areas YOU as parents can be of
enormous help.

One of the first facts we have learned to face
in the last seventeen years is that many bright
students never learn to study efficiently; they have
often gotten along very well with a ‘wait and cram’
atitude, giving textbooks only an occasional cursory
look in time for testing and relying on their innate
ability to absorb information and skills in the
classroom. However, in coming to the MPI, these
same students always find themselves at first, and
suddenly, falling behind.

In general, in college classes MORE
MATERIAL is covered, and MORE SKILL with
concepts is required, i.e., THINKING is expected
regularly. This comes as a shock to many talented
students. One of the MPI’s goals is to expose
students to this shock, and help them overcome it by
learning effective study skills in actual practice. But
YOU as parents can help this transition enormously
by suggesting that your children actually spend the
minimum of one hour per subject, per night of study
that we here at MPI urge. They must come to realize
that longer study times reflect the new rigor of the
COURSES, not their lack of talent. This is a point of
view that many students find hard to accept at first.
Your encouragement can help them over the hump.
Encourage them to seek the help of all the teachers
involved in the program and to put aside the false
idea that only remedial students need to TALK about
mathematics and physics. The fact is that true
understanding comes only from learning to discuss
and explain a subject, and this is ESPECIALLY SO
in physics and mathematics.

Finally, we urge you to call us if you ever
have a question, and we hope that you will find time
to visit the MPI during our OPEN HOUSE on
Sunday afternoon, November 4, 2001. (See the
Calendar in this issue; more about this in the October
newsletter.)

WE HEAR FROM PAST STUDENTS

Rachel (Gard) Wittenberger (94-95)
BS Physical Therapy
University of Missouri-Columbia

“I am married to a 4th-year dental student
who has been accepted into the Orthodontics program
in Iowa. We will move there this summer where I
will complete my MBA degree. MPI was a
challenging, wonderful experience. My problem-
solving skills were greatly developed, and I made
some great friends in the process!”

Hattie Williams (94-95)
BA Psychology, Philosophy, Sociology, UMKC
MS Instructional Design & Technology
Emporia State University

“I’m an MPI alumnus from way back in the
1900’s. Yep, we thought only waiting 10 minutes for
information from China to appear on your screen was
soooooo kewl. I’ve been extremely busy since then.
I graduated from UMKC with BAs in Psychology,
Philosophy, and Sociology in 1999. I received my
MS in Instructional Design and Technology from
Emporia State University this past December.
Currently, I am employed by Sprint PCS as an
Educational Consultant, and so I found the followup
on your enrichment speaker extremely interesting.
...Oh well, gotta go. Good Luck year 18 students!!!
(I got through by the skin of my teeth.)”

Lyndsey Main (99-00)
Computer Science Major
UMKC

“Just wanted to drop a note to everyone at
MPI and tell you that I am transferring to UMKC in
the fall and getting my own place near the Plaza.
School here [the University of California-San Diego]
is great but it turns out it is just way too expensive.
I am looking forward to the move (especially because
dorm rooms are so tiny here!) and I am planning
on a Computer Science major (with possibly an art
minor for some fun graphic design/imaging skills). I
just registered for classes this week, and I am
enrolled in Calc III so wish me luck. I’m a little
scared! I am also taking digital imaging 1 and CS
problem solving II. (I may have to wait on the CS
classes until later though. I learned to program here
in Java and they teach it in C at UMKC. Oh well,
anywho, I may see you around campus in the fall.
Hope everything is going well there and don’t take it
too easy on the kids during finals. RULE WITH AN
IRON FIST. ☺”
Audrey (Linville) Fox (88-89)
MS Chemistry

"Since so much has changed in our lives after we were married in 1993, we decided to give you an update. In October 1998, I gave birth to our son Maxwell (named after James Clerk Maxwell of electromagnetics fame). As he has grown, the choice of his name has seemed fitting since he can count to 12 by himself (and in the correct order!) and he won't turn 3 until this October. After his birth, I left graduate school with a master's degree in Chemistry so I can care for him full time. Jon continued and was rewarded with his doctorate in Physics in 2000. In April of that year, he joined Research Support Instruments at Princeton, NJ. Jon can give you a better description of his research projects in another email. The New Jersey branch of RSI is small so he does his research in collaboration with the Applied Physics Group at Princeton University. He has shown that you can do physics and still eat relatively well. I have included our email addresses in order to update your records. I have also included our US Mail address so that we can receive the newsletters again."

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A SOLUTION TO MATHEMATICS CHALLENGE #68

Recall the problem statement:

The arms of an equal-length balance are never exactly the same length. To eliminate the error due to this unavoidable fact, someone proposes that objects be weighed twice, once on each side of the balance, and then the average used as the correct weight of the object.

However, show that in fact the average of these weighings never gives the correct weight, unless the arms are exactly the same length! In view of this, determine how the weighings ought to be treated in order to truly give the correct weight.

[From: Pi Mu Epsilon Journal, 1950, vol. 52, #2, as quoted in Mathematical Chestnuts from Around the World, by Ross Honsberger, MAA, 2001, section 6, problem #1.]

SOLUTION:

In the picture below, let the equal-length balance AB have its fulcrum (balance point) at F. Let the arm AF have length a, and the arm BF have length b, as shown.

Following the suggestion in the statement of the question, let us weigh an object of unknown (non-zero) weight W twice, once on each side of the balance. Suppose that when placed at point A, the weight W balances with a known weight S, and when placed at point B, the weight W balances with a known weight T, as shown below.

Then, by the Law of the Lever, it follows that both

\[ aW=bS \quad \text{and} \quad aT=bW. \]

Dividing the first equation by the second equation then yields

\[ W/W = S/W = \sqrt{ST}. \]

The expression \( \sqrt{ST} \) is called the Geometric Mean of S and T, while the average mentioned in the statement of the question is \( (S+T)/2 \), called the Arithmetic Mean of S and T. It is well-known that

Geometric Mean \( \leq \) Arithmetic Mean,

and these two Means are equal only when \( S = T \). (The easy proof of this fact for two numbers S and T begins with the obvious inequality \( 0 \leq (S-T)^2 \), followed by multiplying out the right side, rearranging terms, and eventually taking an appropriate square root.)

So, in general, the correct weight W is given by the Geometric Mean. The average (Arithmetic Mean) of these weighings S and T never gives the correct weight W, unless S = T. In that case, using the Lever equations above we can write

\[ (a/b)W = S = T = (b/a)W \]

\[ a/b = b/a \]

\[ a^2 = b^2. \]

Since a and b are both greater than or equal to zero, we conclude that a=b, meaning the arms are exactly the same length, as predicted.

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A SOLUTION TO PHYSICS CHALLENGE #59

Continuing on this same theme of Impulse and Momentum, consider this problem from one of our exams: Two boys in a canoe toss a baseball back and forth. What effect will this have on the canoe?
a. None, because the ball remains in the canoe.
b. The canoe will drift in the direction of the boy who throws the ball harder each time.
c. The canoe will drift in the direction of the boy who throws the ball with less force each time.
d. The canoe will oscillate back and forth always moving opposite to the ball’s motion.
e. The canoe will oscillate back and forth in the direction of the ball’s motion.

**SOLUTION:**

The answer is d. Assume the boys in the canoe are a closed system and that momentum is being conserved. When the first boy throws the ball, he exerts a force that gives the ball momentum in the direction of the other boy. In order for momentum to be conserved, there must be an equal amount of momentum to the boat in the opposite direction. So the boat will move opposite to the ball. Of course, the boat will NOT move as quickly as the ball because MOMENTUM is conserved and momentum depends on both mass and velocity. Since the boat (with the boys) is much more massive than the ball (unless they are throwing one VERY heavy ball!), the boat will probably only move slightly. This motion will always be opposite to the ball’s motion.

**MATHEMATICS CHALLENGE #69**

In the picture below, three circles of radius 5 are arranged side by side in a row. From the point A on the first circle, which is in line with all three centers, a line AD is drawn which is tangent to the third circle as shown.

What is the length of the intersection BC of that tangent with the middle circle?

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**PHYSICS CHALLENGE #60**

Stuck on a windless day, a sailor decides to direct a powerful fan which he has on-board into the sail. If all the wind generated bounces backward off the sail, could this propel the sailor’s boat?

**Editor/Writer:** Richard Delaware

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