

# A TIME FOR PHYSICS FIRST

ACADEMY FOR TEACHERS - INQUIRY AND MODELING EXPERIENCES FOR  
**PHYSICS FIRST**  
 For 9th grade science teachers

A TIME for PHYSICS FIRST

NEWSLETTER: Vol 2, No. 3, December 2008

## PHYSICS FIRST COLLABORATIONS

Kristin Pierce and Stephanie Allen,  
 Oakville High School

One of the most helpful things generated by the Physics First process has been the informal collaboration among teacher colleagues. We wouldn't be nearly as successful without the other teachers in our building. Some of the ways we collaborate include:

- "Mini" lesson studies - One teacher might teach a lesson, struggle with an aspect of it, and between classes brainstorm with the teacher down the hall to find a way of teaching it differently the next hour.
- Polishing labs - Because we share equipment, one person may write a lab, teach it, and share the successes and problems for the next person to fix. By the time the lesson has been through all four teachers, we have a polished laboratory.
- Testing different methodologies - When we have different ideas about how to teach a lesson, we each try a different way and compare notes about students' responses or difficulties.
- Reviewing curriculum - Since the majority of us are not originally physics teachers and the curriculum is still relatively new, we use each other to refresh our memories about things we might have forgotten.
- Writing lessons and practice sheets - One teacher might write a new handout for a lesson, but have the other teachers check it for correct terminology and clarity. The other teachers may modify it. Our school now requires common final assessments in December and May. Ours is already finished - some of us used them last year, and the four of us updated it.
- Working with math teachers - Three years ago, the response of our math department to the new Physics First program was "don't teach them slope." Now,

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*Physics First participants at the September 2008 follow-up meeting*

we meet with math teachers informally and brainstorm ways to help students learn about slope.

- Support - After spending so much time working together through the Physics First training, we all know what the others are going through. Since we all teach freshmen, we can empathize with their behaviors and be a sounding board for each other.

These collaborations allow us to help each other rather than agonize over solving problems individually. The relationships we build also help us go beyond our individual capabilities.

# CAPITALIZING ON MATHEMATICS TEACHERS:

## IDEAS FOR HELPING STUDENTS WHO STRUGGLE WITH THE MATHEMATICS UNDERLYING PHYSICS FIRST

James E. Tarr, Learning, Teaching and Curriculum, University of Missouri, Columbia

These days, science teachers are teaching more than just science. In fact, teachers of Physics First report that they are also teaching a lot of mathematics, more than they ever expected. Without question the Physics First curriculum is laden with mathematics, from algebra to geometry to measurement to statistics. Moreover, with its many laboratory activities, data collection and analysis are inherent to the study of science, uncovering the relationship between Force, Mass, and Acceleration, and between Current, Voltage, and Resistance, and other variable quantities. It follows that students in science classrooms experience many of the same struggles in learning mathematical concepts that underlie the Physics First curricular materials.

In this summer's Physics First academy, mathematics teachers sought to address the needs of their science teacher colleagues by offering their best ideas for teaching two key elements in the study of algebra, namely graphing and symbol manipulation. In particular, they began by considering the many challenges associated with graphing: labeling the axes, plotting points, drawing graphs and interpreting graphs. Any one of these four aspects of graphing offers many specific challenges. Consider, for example, labeling the axes of a graph. Students must identify the *independent* and *dependent* variable, decide on the *correct unit of measure* for each axis, decide on an *appropriate scale*, decide *how much each interval should represent*, realize that *scale need not be the same* on both axes, make certain that *equal intervals* are used in labeling a given axis, and decide whether or not to *start each axis at 0* or begin with a different value. Sounds simple enough, yes? Actually, *all* of these aspects must be addressed before plotting points, drawing graphs, and making interpretations. With respect to deciding on an appropriate scale, mathematics teachers suggested:

a. Using a graphing calculator to view a graph with different window settings to show effect of scale on appearance of graph

b. Having students determine the upper and lower bounds prior to deciding on an appropriate scale

c. Using number lines to count by different increments to keep intervals constant, and

d. Before plotting any points, allowing students to count aloud to learn if their axis will go out far enough to plot the points and, if not, adjusting what they count by so that all points can be plotted.

The collective ideas brainstormed by mathematics teachers were compiled and were posted on the project web site.

Teaching symbol manipulation continues to be a nemesis for mathematics teachers as well as science teachers. In short, there is no "silver bullet" to resolve these ongoing struggles, but a few suggestions may be fruitful for some science teachers and their students. Consider the Physics First equation  $\text{Force} = \text{Mass} * \text{Acceleration}$ . If the values of Mass and Acceleration are known, then solving the equation for Force is straightforward: simply substitute in values for M and A and multiply. But what if we need to determine Acceleration from Force and Mass? Although this "new" problem is related to the original one, it is significantly more challenging because it requires additional steps. Mathematics teachers offered many ideas to Physics First teachers. For example, they suggested:

- Substituting in hypothetical values for Force and Acceleration:  $24 = 4A$ ;  $60 = 12A$ ; and  $32 = 8A$ . Students should be familiar with equations such as these, having experienced them in Prealgebra. By doing several examples, teachers can show that the same operation is being used to solve for Acceleration, namely division.

- Pointing out that Acceleration is multiplied by Mass, and so to "undo" multiplication, we must *divide* both sides of the equation by Mass. By drawing a line down the page to separate the two sides of the equal sign, one can make sure the same operation is being done to both sides of the equation.

...continued on page 3

# FROM TEACHING ASSISTANT TO TEACHER

Justin Riffle, West Jr. High School, Columbia

Let's be honest. Considering the fact that I knew I would be teaching physics in a high school classroom eventually, I probably should have spent more of my three summers as a Physics First teaching assistant looking at the program through that lens. I should have listened a bit more intently to the musings of the participants as they discussed issues their students would have with the material. In my naïveté as a physics education undergraduate who had very little trouble with the subject during my own high school years, I doubted that any student would have difficulty with this material, being that it was so ingrained in my mind. I have since learned.

Despite a curriculum that I consider to be quite solid and highly based in inquiry practices, students still have struggles. It is my belief that some of them may simply lack the cognitive maturity to comprehend a variety of the topics we cover. That being said, the students strike me as having a wide array of cognitive abilities. A few high-level students grasp material quickly and find the time spent on concepts unnecessary and even boring. They seem impatient with the extra time inquiry lessons demand. For the kids who need conceptual work, I find that the curriculum works quite well. The majority of the Physics

First curriculum is built around the idea that students will understand concepts better if they have a hand in discovering them. I love this idea, but it takes time. While I'm on the topic of getting burned out, the lack of genuine "hooks" is something I never really realized as a TA. I found the vast majority of the material quite interesting, but I'm a physics major—of course I'm going to find it interesting. Ninth graders, on the other hand, may not care less about having a graphical, mathematical, verbal and pictorial description of an object's motion. Creating "hooks" that work for all students is challenging!

Overall, it is my judgment—as an inexperienced first year teacher fresh out of being a Physics First teaching assistant—that the curriculum we have to work with is quite solid. The framework of inquiry is imperative to meaningful learning. The multiple representations of concepts are sure to help students whose learning styles run the board. I feel like the curriculum could benefit from a small trimming of some of the less-than-essential components and a boost in engaging hooks. The structure of a solid curriculum is there, with a few adjustments facilitated by meaningful teacher and developer collaboration, the curriculum should last a long time.

*...continued from page 2*

- Asking questions, "What is the variable connected to?" and "How is it being connected?" (multiplication, in this case).

Among mathematics teachers, there were mixed feelings about use of the "Magic triangle" with Force located at the top vertex, Mass and Acceleration at other two vertices; some felt this strategy did not help students to make sense of the interrelationships and how to solve for one variable. Of course, to avoid the problem solving for Acceleration, teachers might be tempted to simply supply students all possible arrangements of the original equation: (1) Force = Mass \* Acceleration, (2) Mass = Force/Acceleration, and (3) Acceleration = Force/Mass. Mathematics teachers (and even science teachers) agreed that this strategy "gives too much away" and does not require students to think. Moreover, there was consensus that, in real

life, at most one formula (not three) will be available.

In summary, mathematics and science teachers need to realize their students experience many of the same difficulties in learning their respective content. This is particularly true in Physics First classrooms where mathematics underlies much of the physics content. Rather than lamenting about "what students can't do," it is more productive to work in a coordinated manner to improve student learning. Mathematics teachers need to become aware of how their students are applying mathematics in science classrooms, and realize that Physics First teachers may feel ill-prepared to teach mathematics. Science teachers need to recognize that mathematics teachers have useful ideas for helping their students with Physics First. Working together, science and mathematics teachers can help all students become successful in learning Physics First.



# PHYSICS FIRST PRESENTS TO THE SCHOOL BOARD OF MISSOURI

Sarah Hill, Physics Department, University of Missouri

The idea first came up at one of the leadership team meetings, in the context of sustainability of the project –how could we get the word out about continuing or duplicating the program for more teachers? The idea of presenting at a state school board meeting took flight and soon we were driving toward the rising sun at 5:30 AM one clear Thursday morning in October.

Preparation for the 8:30 AM meeting at the Doubletree in St. Louis took many forms. With only fifteen minutes speaking time, the information presented must be efficient, articulate and concise. I wondered about the individuals we would be addressing, and how they would react to this information. Upon searching on the DESE website, I soon had an answer; the Missouri school board members were from various walks of life, ages and backgrounds who all had one burning desire in common – to improve education in the state of Missouri. Well, I thought, we want to do that too!

So, a PowerPoint was designed, explaining the three-year history of this project called A TIME for Physics First. We explained the goals and objectives and why this concept of putting physics at the beginning of the high school science sequence is a valid and sensible idea – that physics lays the best foundation for subsequent science coursework and that leading the student from the simple to complex is an approach that is in harmony with the way the brain learns. And, since the 2010 high school graduates in Missouri must complete three science credits compared to the previous two required for graduation, this is a great time to make this change in science curriculum in Missouri. We gave each board member a copy of the PF professional development curriculum, an informational DVD and copies of the Physics First newsletter.

When Sara Torres, project director and presenter extraordinaire, started speaking to the seven board members, she began by thanking all the people who worked together to make this project happen, especially those who attended the meeting that day, and asked us all to stand. When HALF the audience stood, I think the board was more than impressed – they were amazed at this strong show of support. Those attending

included administrators from several districts, coach mentors and several participating teachers. Thanks, most sincerely, to all of you who attended!

At the close of the PowerPoint, the agenda included five minutes for questions from the board. When that five minutes stretched to almost 35, I figured something great was happening – especially when protocol was broken by several members of the audience stepping to the microphone to speak in behalf of the program. Again, the board was duly impressed, I think.

However, the board trained a critical eye on the program as well. Where is the proof, they said? Where is your data? Is this idea of physics at ninth grade compelling enough to invest more education dollars into expanding the program for all 9th grade science teachers in Missouri? We need to see the results of your evaluation data, they said. When you have that information, they said, we can meet again. That makes sense from their point of view, I thought, but that certainly underlines the need to collect and evaluate the classroom data this year!

So, all of you who have worked so hard at learning from this program these last few summers, take note, PLEASE! (that sound you hear is the thump of me jumping on a soapbox) Your help provides an indispensable body of information that is available nowhere else but from your classrooms. The data that you are collecting and sending to me this 2008-09 academic year is necessary, valid and essential. It will provide crucial information to be included in any request for future funding.

We are proud that you continue to work with the Physics First program to build the groundwork for improving science education in this state. You are the pioneers breaking new ground to establish that students from Missouri can compete in the expanding (and increasingly aggressive) market for outstanding science career choices. We hope that you are proud that you are training the scientists of tomorrow, the workforce that could find a cure for cancer, design alternative energy sources and conceive of ways to clean up the planet's pollution. Rock on, Physics First teachers!

# REFLECTIONS OF A COACH MENTOR

Nancy Iannotti, Coach Mentor

It has been two months since I have visited my mentees and I find myself wondering how it is going for them. What do I miss most? Watching teachers grow professionally and watching young people learn. There is something special about Physics First. Not only does the program support worthy content and sound pedagogy, it also encourages collaboration. What did I observe over the two plus years of mentoring? Teachers learning physics in an academy with experts on hand to teach and tutor them, teachers learning the use of equipment that might otherwise be unavailable to them, and units being taught as student-centered, not teacher-delivered, experiences. I only wish all teachers could be supported in this way.

I also observed the reality of committing to a program like this one. Teachers giving up 3-4 weeks of each summer over a three year period, time spent in weekend meetings, grading pre-tests and post-tests, all layered on the expectations of districts, schools and departments. In many cases class sizes challenged the teachers even further. This reality only increased my respect for those who persisted in developing a Physics First program.

In the classroom I observed the skillful use of white-boarding when students were answered questions with *more* questions and encouraged to *interpret* data as well as report it. Over the course of these two years, as one teacher put it, “delivery shifted to discovery.” I watched students use sophisticated equipment with great ease and confidence and couldn’t help but

wonder what this might pave the way for in subsequent science courses. In facilitating Lesson Study, I heard teachers “debate” the target objective, even after being reasonably confident that the lesson was planned. This type of reflection continued as they developed assessments to determine if the objective was achieved. The success of the lesson would be measured by student *understanding*.

This brings me to the PF objectives. Linda Kralina and I took on the task of reviewing the objectives with the goal of organizing them from unit to unit into a common format. Our hope was that this would assist the teachers in communicating to their students what they were accountable for in each unit. What an eye opener that was! Taking a second glance at the breadth and scope of the objectives further elevated my appreciation of this course and of its teachers. The process generated much discussion since we wanted each objective to be an accurate statement of the learning outcomes determined by the writers of each unit. It evolved into a formidable project!

As I conclude my reflections, my thoughts return to the people I have worked with - the dedication of the leadership team, the peer teachers, my fellow coach mentors, my mentees, and the mentees I got to know in the academy. I sincerely hope things are going well in the classroom this year and I am confident that our student physicists are benefiting from the outstanding preparation and efforts of their teachers.



*Physics First teachers in a collaborative mood at the September follow-up meeting*



## WORDS FROM SARA

Sara Torres, Columbia Public Schools

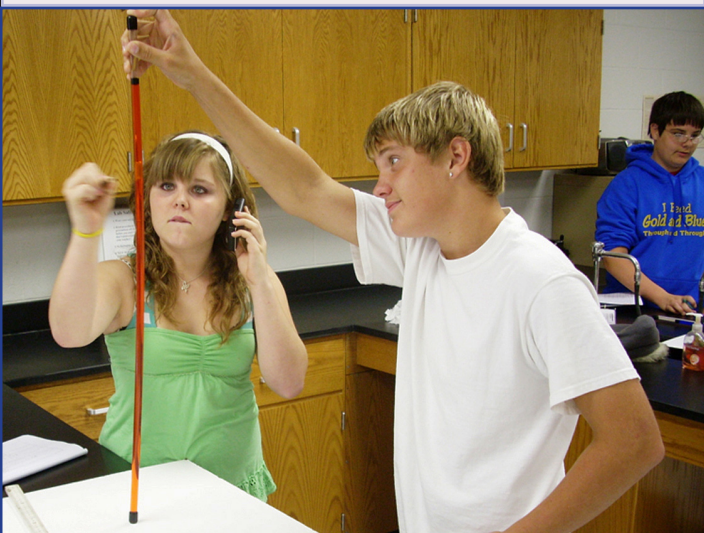
During the State School Board meeting in October, a presentation on A TIME for Physics First was given. The board members were very interested in the program. They asked questions regarding the relationship between mathematics and science teaching, student achievement, and courses taken by students later in high school. They were also interested in learning about other schools nationwide that are offering the same science sequence. Their genuine interest and questions assured me that they were supportive of the program.

To answer some of the State School Board members' questions, we must continue to research and to collect data. Thus, it is imperative that Physics First teachers send in their pre- and post- test scores to Sarah Hill. Therefore, we can send the State School Board an update of our progress.

As 2008 comes to a close, it is always valuable to reflect back on the year. I am so grateful for everyone who contributed to the success of A TIME for Physics First - teachers, administrators, Coach-Mentors, members of the Curriculum Committee & Advisory Board, the students, the teaching team, and the leadership team.

I am looking forward to working with you in the future! Happy Holidays!

Sara



Students at Elsberry High school conduct the bubble tube lab

## THE FINAL PHASE OF PHYSICS FIRST

Glenn Owens, Coach Mentor

Funding for the Physics First grant is over, but the program continues. As a Coach Mentor, I had the privilege to observe as the concept of PF developed in six different school systems. There were variations in the schools, some of the teachers were relatively new to the field and some were experienced. That being said, one common trait that I observed was dedication to the craft on the part of the teachers.

In my three years as Coach Mentor, there were some changes. Teachers were transferred to other schools within a district; new teachers were added to the program the second year; teachers moved to other school systems and Coach Mentors were re-assigned to different schools. However, the program itself remained consistent throughout the period of the grant.

Because this program was funded by a grant, the final phase is somewhat challenging. Funding ended in September 2008, but teachers still have an obligation to collect and submit data to the project. This part makes me especially proud of the PF teachers. Even though they will not receive further reimbursement, all teachers in the schools that I observed have matter-of-factly stated, "Of course I will continue to collect data and send it in. That was part of the deal. Besides, 'pre' and 'post' tests are good for me and good for the students." This reasoning makes perfect sense. By giving a 'pre' test, the students have an idea about material that will be covered and the evaluation. After scoring the 'pre' test, teachers have an idea about students' knowledge and can make a more effective lesson plan. When I asked about the time required to grade the tests, the teachers said, "It generally does not take much time to grade the 'pre' tests because the students don't know much; and I use the 'post' tests as their test grade for that unit anyway."

The only regret that I have is that the program will not continue to grow, as it should. The Summer Academy and the follow-up meetings were wonderful experiences for the teachers. It gave them opportunities to try new things, to network with teachers from across the state as well as real time to visit with teachers in their own schools. New teachers were able to share things with the more experienced teachers. The support staff in the program learned a great deal as the PF program evolved. Everybody was a winner.

# THE IMPORTANCE OF A GUESS

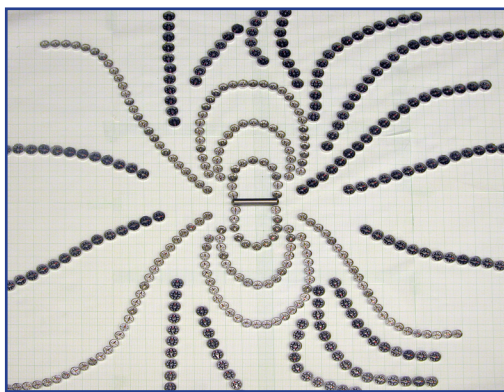
Doug Steinhoff, Jefferson Jr. High School, Columbia

The longer I teach, the more I learn. I've learned that when students make a guess, they open a window into what they are thinking, and what they know. Guesses can be a powerful tool to direct student learning. When we started the Lesson Study program, students were always asked to predict the outcome of their lab. Students are able to open their minds to another line of thinking if only you ask. As teachers, we take what they know and shape it into a model that explains the phenomenon they observe and experience - like when my six-year old daughter thought that the little birdie in the cuckoo clock really knew how to tell time. Or when she was eight and she thought that the sticky door to the basement was known as a "Damn Door." So when she went to the neighbor's house to play and a parent asked if she knew where the basement door was, she said that she already knew where their "Damn Door" was!

The point is that we assume that the kids possess a common basic knowledge of most subjects we teach, but what we don't always realize is that many of them have generated theories of how things work, or why they happen because they take knowledge that most closely resembles what they already know and apply it to generating a theory of explaining situations that you present to them. Here's an example. Think about when your students come into the classroom and you begin talking about electricity. You ask them, how does the electricity move in a wire? When I ask my students this question, they respond many different ways. One student said that the power from the electricity comes from the plug and it moves through the wire at the speed of light to the light bulb in a lamp. When asked, "Where does the power from the plug come from?" they start thinking a little harder and respond, "From the power plant." This automatically starts students generating new models of electricity. Now they think that the electricity comes from the power plant to the lamp. When asked if it takes longer for a house 100 miles from a power plant to light up a light bulb than a house one mile from a

light bulb, then students again re-think their model. "Oh, then electricity must travel at high speeds" they respond. "Probably the speed of light!" Then I follow up by asking, "How does the electricity travel through the wire?"

What I am finding out is what they know about electricity and what misconceptions they have. From here I take their models and we dissect them to find out a better method of explaining what is really happening when electricity travels down a wire. I know what you're all thinking, "What, how can I afford the time to do that when I have to get through eight more units in only three more months???" But I argue, that if you generate a strong knowledge of these basic concepts, your students will find it easier to understand more difficult concepts later, which saves time and confusion. With electricity, knowing how electrons and energy flow through a wire helps students understand current, voltage and even resistance in more depth. This translates to less time pulling your hair out (which some of us can ill-afford) re-explaining these difficult concepts.



WhaZZhat??

You can compare it to the development of the atomic model. It started with Democritus and his model of an atom, "atomos," but was continually disproved until it ended with quantum theory. We take what we believe to be the truth and test it. If our model doesn't explain our results, we re-think our model and maybe generate a new one. This is where powerful learning comes in - like the coach of my daughter's baseball team telling her to run to first base if she got a hit. So she ran to third when she hit the ball back to the pitcher. When she got back home, I asked her why she ran to the wrong base and she said that the coach told her to run to first base and the base on the left was the first base she saw.

How do we know what our students are thinking or to explain why something happens? Just ask them to guess. You might just find out something yourself.



# WHAT MAKES A QUESTION SCIENTIFIC?

Mark Volkmann, Learning Teaching and Curriculum, University of Missouri

Students ask hundreds of questions each day and teachers make hundreds of decisions about those questions. One criterion that a teacher should consider as s/he makes decisions is “What makes a question scientific?” Knowing whether a question is scientific or not will help the teacher keep the class focused.

As you enter a science classroom, you might hear discussion on a number of topics. Imagine you heard the class discussing the following questions. Which of them, do you think, qualify as scientific? Why?

1. Does God exist?
2. Should the US use nuclear power for the generation of electricity?
3. Is mass lost during the combustion of gasoline?

These questions are interesting and may generate good discussions, but are they scientific?

Question #1 – Does God exist? Is this a scientific question? A criterion used to judge whether a question is scientific is to ask if the question deals with the way the natural world works. Science focuses on understanding life events such as growth, heredity, and reproduction; Earth events such as volcanoes and earthquakes; astronomical events such as moon phases and supernovas; and physical events such as burning and boiling. These understandings are contained in the natural world. Religious questions such as “does God exist?” are based in the spiritual world, outside the domain of science. While the existence of God is a provocative idea, should it be discussed in a science classroom?

Question #2 – Should the US use nuclear power for the generation of electricity? Is this a scientific question? Does this question deal with events within the natural world? One might argue that since nuclear power qualifies as a natural world phenomenon, it is scientific. However, the question calls for a moral decision. Moral questions are based on ethical values and these values reside in the social world. As such, moral, ethical, or legal questions cannot be addressed by science. While it is true that science may provide information about the benefits and risks of these choices, science cannot answer the question in a direct manner. While this question may lead to scientific re-

search, science teachers must take care to focus attention on natural world questions that can be answered through scientific effort. Questions such as “how long does nuclear waste remain radioactive?” Or “how does radiation damage human life?” reside in the natural world and can be answered by gathering empirical (natural world) evidence.

Question #3 - Is mass lost during the combustion of gasoline? Is this a scientific question? Does this question deal with events within the natural world? One might argue that since we are talking about the combustion of an engineered product – gasoline – that it does not qualify as a natural world question. However, the combustion of gasoline is representative of a great number of combustion events. The idea of interest – combustion – is a natural world phenomenon and any substance that combusts, whether it is engineered (paper for example) or not (wood for example), obeys the same set of conservation laws – i.e., mass is conserved during physical and chemical changes. This question resides squarely in the natural world. It can be investigated by gathering data from the natural world and as such, it qualifies as a scientific question.

The next time a student asks a provocative question – aimed at taking the class to a new topic – ask yourself, “*is this a scientific question?*” Hopefully, this discussion will aid your thinking and help you make the instantaneous choices that students expect of us.



Poplar Bluff High School students



# TEACHING AT THE VIRTUAL SCHOOL

Becky Baker, Missouri Virtual School, Missouri State University

The Missouri Virtual School (MVS), operating out of Missouri State University, has existed since 1999 and offers synchronous and blended (combined aspects of synchronous and asynchronous) distance education classes. Each class is usually supported by a Moodle site as well. MVS was created in response to the limited number of mathematics and science teachers graduating in Missouri and the lack of opportunities for students in southwest rural Missouri to take advanced classes in those areas. It evolved quickly to include foreign language classes and now, in 2008, offering classes in all subject areas as needed across the State of Missouri.

Classes are delivered using two main formats – one, through the use of a videoconferencing unit which allows two-way audio and video and the second is through a web-conferencing format which offers two-way audio with shared whiteboard capabilities and application sharing along with a number of other tools that let you conduct class in a variety of ways.

It is always interesting talking to people about the way I teach. The assumption is that we are just “talking heads” and very little interactions between students and teacher occurs. While the interactions are not the same as being physically present in the classroom, interactions between myself and the students

do occur and can be as rich and as interactive as any classroom. You can forget you are in front of a camera and not physically present. My favorite story demonstrating that occurred while teaching physics at Strafford High School. We were intently working on problems – some students were working at the board, some at their desks on whiteboards which they would hold up and show me their problems. One of my students needed a calculator that did trig functions. He asked to borrow mine and I reached out to hand him my calculator. We both realized at the same time there wasn’t any way for me to “hand” him my calculator. We were not physically in each other’s space. We both laughed and decided we needed Star Trek’s transporter beam. It was at that point I realized the technology had really become transparent and it no longer mattered where we were physically located – we were both in the same learning environment.

Over the years we have been teaching courses out of MVS, the technology has become more mobile. Initially, when videoconferencing was put into schools, the units were placed in formal “distance education rooms” that used DSL lines to transmit the signals. Now, a number of schools have their videoconferencing units on carts that can be rolled from one classroom to another with the only requirement being an Internet connection. Now, “have unit – will travel” is our motto.

The laboratory component of our science classes has always been a concern and the mobility of the videoconferencing units has greatly simplified our ability to conduct laboratory activities. Labs activities are a very important part of class and we had to figure out a way to make sure that each component was covered. I can now “follow” my students to the science lab or the library if needed for research. All of our classes have a facilitator in the lab with them as well as the instructor. We also do demonstrations, virtual labs, online simulations and visit the schools at least once a semester to conduct on-site labs. We aren’t completely there yet in making the laboratory component what it needs to be but we are making progress.



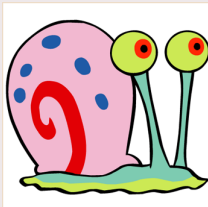
*Elsberry High School students*

# BRAIN BENDERS

Dorina Kosztin, University of Missouri

## 1. A SNAIL IN A WELL

A snail is at the bottom of a thirty-meter-deep well. The snail climbs up three meters in one day. During the night, the snail slides back two meters. How many days will it take the snail to reach the top of the well?



## 2. DRY SHELL, WET SHELL

A shell is tied to the side of a boat such that it hangs 3 meters above water level. The water rises 2 cm every hour. How much time will it take before the water touches the shell?

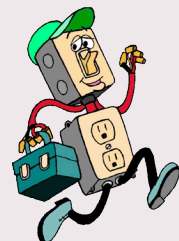


## 3. HAIRY BEARY

A bear walks south for one kilometer, then it walks west for one kilometer, then it walks north for one kilometer and ends up at the same point from which it started. What color was the bear?

## 4. THE TALENTED ELECTRICIAN

An electrician has two two-way switches, a light bulb, and a power source. How should he connect the terminals so that either switch can be used to turn the light on or off?



## 5. BURNING SHIP

A ship is in flames on the high seas. All sailors, except for the captain, leave aboard life boats. The captain dives and swims under water for 90 meters. He hears an explosion. When he surfaces, he immediately hears another explosion. The captain rejoins a life boat and is pulled aboard by the sailors. The captain mentions that he heard two explosions. The sailors state that they only heard one explosion. Both captain and sailors are telling the truth. How is this possible?



Answers will be published in the next newsletter. If you just can't wait until then, email Sarah Hill ([hill-sar@missouri.edu](mailto:hill-sar@missouri.edu)), and we'll send you the key.

## Answers to August 2008 Brain Benders

### 1. HOLLYWOOD PHYSICS

*In a movie, the bad guy is stationary and fires his gun at point blank range (ie extremely close) to his stationary victim's chest. The bullet has a mass of 0.025 kg, leaves the barrel of the gun at a speed of 500 m/s and comes to rest inside the victim. The victim has a mass of 100 kg. Assume that all the momentum of the bullet is transferred to the victim. Determine the speed of the victim's body as a result of the impact of the bullet. In the light of your calculations, comment on the accuracy of movie scenes where the victim's body is actually thrown backwards by the bullet's force of impact.*

Answer: The momentum of the bullet is given by

$$p = m \cdot v$$

$$p = 0.025 \times 500$$

$$p = 12.5 \text{ Ns (or kg} \cdot \text{m/s)}$$

If all of this momentum is transferred to the victim,

$$12.5 = 100 \cdot v,$$

where  $v$  = speed of victim after impact of bullet. Therefore,

$$v = 0.125 \text{ m/s}$$

The speed of the victim after the bullet hits is 0.125 m/s, or 0.45 km/h, or about 12.5 cm/s – is not a very high speed. The speed of a person walking for exercise can be as much as 10 km/h. It is therefore very unlikely that a person who is shot will be lifted off his feet and thrown backwards. Physics shows that such scenes in movies are often inaccurate.

<http://webs.mn.catholic.edu.au/physics/emery/brain teasers.htm>

### 2. THE PUNCTUAL KNIGHT

*A knight wanted to visit a princess. He had to arrive at exactly 5:00 pm. If he were to travel at 15 km per hour, he would arrive one hour too early. If he were to travel at 10 km per hour, he would arrive one hour too late.*



- a) *At what time did he leave to arrive at 5 pm?*
- b) *What distance did he travel?*
- c) *At what speed did he travel?*

Answer: He left exactly at noon, traveled at 12km/h, and rode a distance of 60 km.

<http://www.pedagonet.com/brain/brainers.html>

### 3. THE HIGH-RISE KID

*A young boy, one meter tall, lived with his parents on the tenth floor of an apartment building. When leaving for school in the morning, he would use the elevator to get to the ground floor. When returning from school, he would take the elevator to the fifth floor. Then, he would get out of the elevator and climb the stairs to the tenth floor. Why did he not use the elevator to get to the tenth floor?*

Answer: He was too short to reach the button for 10th floor.

<http://www.pedagonet.com/brain/brainers.html>

### 4. ROW-ROW-ROW YOUR BOAT

*John, his wife, and their daughter wish to cross a river. The row boat can only hold 100 kilos. John weighs 80 kilos, his wife and daughter weigh 40 kilos each. How is it possible for all three to cross the river?*

Answer:

Mom and daughter cross first.

Daughter gets out of boat, mom returns.

Mom gets out of boat, dad crosses.

Dad gets out and daughter goes back to get mom.

<http://www.pedagonet.com/brain/brainers.html>

### 5. USEFUL HOLES

*If you examine a modern parachute you will notice that it has a large hole at the top. Why is there a hole in the parachute?*

Answer: By allowing the air to leak slowly out of the top of the parachute, the hole stabilizes the parachute and allows for safer landings than old-style parachutes without the hole. The old parachutes produced a back-and-forth pendulum-like motion caused by air leaking out from the edges of the chute. As the air leaked from one edge, the chute tilted, throwing the parachutist to one side. As the chute swung back, more air would leak out from the opposite side, causing the pendulum motion.

The hole also slows down the opening of the chute, causing a more comfortable opening.

<http://webs.mn.catholic.edu.au/physics/emery/brainteasers.htm>

## CONFERENCE PRESENTERS FALL 2008

### STOM, JEFFERSON CITY, SEP. 26-27

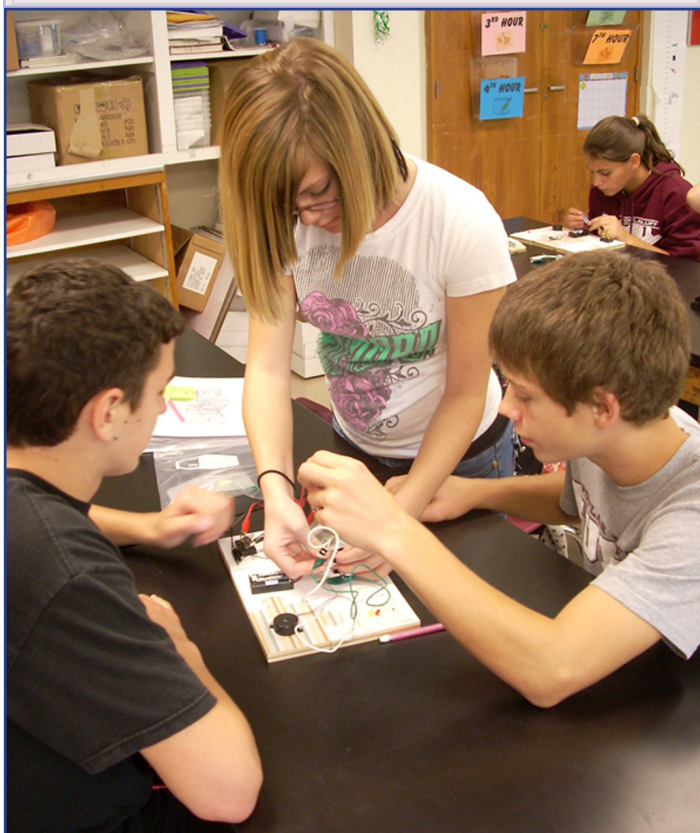
*The Physics First Initiative in Missouri*, Sara Torres and Stephanie Harman

*Using Inquiry and Modeling to Study Electrical Resistance*, Andy Graf and Dustin Pearce

*Energize Using Inquiry and Modeling*, Amy Campbell and Dorina Kosztin

*The Nuts and Bolts of Lesson Study*, Tara Frearson and Sara Torres

*Physics with Bowling Balls*, Richard Muschett



*Poplar Bluff High School students*

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*Left: Students at Polplar Bluff High School investigate electrical circuits using a puzzle board  
Below: Students at Elsberry High School explore uniform motion using bubble tubes*



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