

A TIME for PHYSICS FIRST

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ACADEMY FOR TEACHERS

INQUIRY AND MODELING EXPERIENCES FOR PHYSICS FIRST

LEADERSHIP IN FRESHMAN PHYSICS, 2009-14



Supplement to Vol 5, No. 2, August 2011

REFLECTIONS ON THE SUMMER MATHEMATICS ACADEMY AT A TIME FOR PHYSICS FIRST, 2011

During the week of June 13-17, 2011, mathematics teachers from participating high schools in Missouri attended the second Physics First Summer Academy on the University of Missouri Columbia campus. This gave them the opportunity to work collectively as a group as well as to attend Physics First classes with their science teacher colleagues. In the process, mathematics teachers have familiarized themselves with key components of the Physics First curriculum and pedagogy, engaged in discussing implications for the mathematics curriculum of the Physics First course, explored in group discussions their role in implementing the Physics First curriculum in their respective schools, established the basic working parameters for an on-going collaboration with their science colleagues (as it relates to the Physics First course), deepened their mathe-

matics content knowledge and their problem solving skills, and had the chance to meet with administrators to bring forward their suggestions regarding ways in which administrators may help facilitate the collaboration that needs to take place between the mathematics and science teachers at the schools implementing the Physics First course.

-- **DORINA MITREA, PROFESSOR OF MATHEMATICS, MU**

The letters below were written by mathematics teachers attending the summer academy. They are addressed to mathematics teachers who were unable to attend the academy with the goal of providing insight into the needed collaborative effort between the mathematics and physics teachers.

DAVID TIDWELL, HANCOCK PLACE:

In collaborating with the Physics First teachers and other Mathematics teachers over the past school year and last two summer sessions, I have learned many ways to help assist and collaborate with Physics First teachers. I have compiled a list of suggestions and vocabulary to share with other mathematics teachers to hopefully effectively assist and provide discussion topics with Physics First teachers.

- Ask the Physics First teachers to compile a list of formulas used throughout the school year. These formulas can be incorporated throughout the year in many al-

gebra lessons. For example, when teaching students to solve formulas for a specific variable, using real-life formulas that they will see in Physics First would be ideal problems to use.

- Determine a rough draft of the timing and scope and sequence on concepts taught in Physics First and concepts taught in Algebra. These concepts do not necessarily need to be taught at the same time, but it would be important to be aware of when each class teaches each concept.
- Discuss the idea of graphing functions with independent variables and dependent variables. In Physics First, "x" is sometimes used to

represent the position variable, and is plotted along the vertical axis. The letter "t" is sometimes used to represent time, and is plotted along the horizontal axis. A discussion on how to help students understand the underlying concept (and not get stressed out about the letters used) would be beneficial in this case.

- Physics First uses many variables with subscripts. Mathematics teachers could use these variables with subscripts to help students understand what they stand for. For example, one could say the formula for the area of a rectangle is $A = l \cdot w$ or in a slightly changed formula, $A_R = l \cdot w$ where the sub-

script represents the area of the rectangle. Another mathematics teacher suggested an example of having three students named Tiffany in the same class. Each student could be described as T_1 , T_2 , T_3 or classified by using the subscript letter of the first letter of their last name.

- Mathematics teachers can use real data collected from student experiments from the Physics First class to use in the mathematics class. This real-life data is relevant to the students and can be used to increase understanding of graphing and to teach students how to write equations of best fit and how those equations can be applied in the real world.
- Physics First stresses to students to label mathematical calculations with units and will “cancel” units to come up with final answers. This could be introduced and used as needed in the classroom per discussion with the Physics First teacher and other mathematics teachers in the school/district.
- Discuss how to find the area under a graph and the real life application of what this “number” represents in physics.
- Discuss the use of whiteboarding and how it could potentially be used in the classroom
- Slope is used often and sometimes the formula is seen many different ways. A discussion with colleagues about the most frequently used ways to calculate the slope in both mathematics and physics classes would help make everyone aware of how it is used in both classes. This doesn't necessarily mean that both Physics First and mathematics teachers need to use the exact notations. This is just to make both parties aware of each other's practices.

- There are many slight changes in formulas that may be encountered. For example, in a mathematics class, a student might use the formula $D = r \cdot t$, and in the Physics First class, a student might use the formula $D = s \cdot t$ or $\Delta x = v \cdot \Delta t$. It would be beneficial share with students that although the variables are different in each scenario, the idea is still the same.
- It is good to get an understanding of certain vocabulary words and symbols that show up often in Physics First. A few words that could be discussed as a collaborative team could include definitions of displacement, work, slope, velocity, vector, and force.
- A discussion about the use of decimals, fractions, scientific notation, etc. in each class might also be beneficial.
- There were many more ideas and concepts learned throughout the time spent here. One of the best resources and discussions is the collaboration with other mathematics teachers. Sharing ideas and thoughts is a great way to increase student learning in the classroom. I would highly suggest sharing email addresses with other mathematics teachers in the hopes that discussions, ideas and suggestions can continue throughout the year.

$$v_f = v_i + a \Delta t$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$E_k = \frac{1}{2} m v^2$$

SANDY DAVIDSON, MOBERLY:

I am sorry you could not attend 'Physics First' where we learned several fun applications between math and physics. Don't worry, with open lines of communication between your school's Physics First teacher and yourself, you will be able to catch up on what we learned. Here are some key points to help get you started.

Physics has a lot of labs that produce data that in turn can be extended in your math class. Instead of creating random data to teach or extend a topic in your classroom, you can use the data from physics labs. Furthermore, you can use physics formulas as examples to have students solve for variables to increase their familiarity. When creating real-life examples of slope and quadratics, simply use situations from physics.

A big misconception for students you as a math teacher can help prevent deals with slope. In physics, they have x on the y -axis as position. We have x on the x -axis. Now, when students try to find slope by putting x -values on top instead of in the denominator, you can help explain this. In addition, really emphasize using different variables when finding slope so students have to remember the change in the y -axis (Δy) over the change in the x -axis (Δx).

You can help students with their physics by having them explain graphs compared to its labeling. What does it really mean at the point (x,y) ? For example, at time 5 seconds, the rock is 3 feet above ground level. Of course, there will be many pay offs within your math class as well.

If you can collaborate with your physics teacher and get similar ter-



Math and Physics First teachers discuss results of their experiments: L-R: Emily Augustine and Cathy Dweik, math and physics teachers, respectively, from Jefferson Junior High School; Lisa Grotewiel and Randall Siddens, physics and math teachers, respectively, from Keytesville High School

minology then students can spend more time on solving problems.

When students see a cyclical teaching of slope, graphs, units, problem solving ... between physics and math the students will be better for it. I hope you have a wonderful year with great collaboration between you and your physics teacher.

SARAH DOSS, WILLOW SPRINGS R-4:

I have to admit my hesitation in regards to freshman taking Physics First, feeling that the combination of Algebra and Physics was too much for them at their level of development and math skills. However, upon completion of the academy, this order is beneficial. The skills they learn in Physics can and do complement higher order thinking, which is the base for the other science courses.

So how can Algebra complement Physics and vice versa? There are multiple ways the two use similar terminology and concepts, thus strengthening the students' skills in the long run.

How does this transition begin? As math teachers we can start using units. This is an easy way to merge. Then go over curriculum and what the two classes can do to support

each other ... in slopes, graphs, etc. It would be helpful to no longer say that, "That is wrong," but instead challenge ourselves to explore the possibilities.

Isn't that what math is about, exploring the possibilities? Math and science departments working together ... imagine the possibilities? Most importantly, imagine how much more the students would learn from this marriage? It's exciting to think about.

SCOTT NEEMAN, SPRINGFIELD R-12:

Recently a group of math teachers including myself had the opportunity to attend a week of Physics First training in Columbia. During this time we identified some areas where math and Physics First teachers can work together to strengthen students' skills in both math and science. While the Physics First curriculum requires dramatic changes in the science classroom, math teachers can assist the implementation of this new curriculum by making a few very minor changes in their teaching.

Evaluating expressions and solving equations

Instead of using generic expressions exclusively, teachers can also include some examples from the

Physics First material. For example, in the equation for the position of an object in accelerated motion,:

$$x_f = x_0 + v_i t + \frac{1}{2} a t^2$$

Teachers could provide four of the values and have students evaluate or solve for the other. This example also provides an opportunity to discuss subscripts and units of measure.

Slope

Math teachers typically define slope as rise/run or $(y_2 - y_1) / (x_2 - x_1)$ or some similar way. It can also be defined as vertical change / horizontal change which would help the Physics First curriculum because their axes do not always have x on the independent axis and y on the dependent axis. For example, they may have time on the dependent axis and x (displacement) on the independent axis. Additionally, when analyzing slope on the graph, it will help to use increments other than one on the axes.

Area

When calculating composite areas, include some piecewise linear examples. Additionally, area problems provide another opportunity to analyze units of measure in your calculations.

It is our belief that when implemented with some cooperation be-

tween math and science teachers, the Physics First curriculum will deepen students' understanding of mathematical concepts.

RANDALL SIDDENS, KEYTESVILLE R-3:

As a first year teacher, I have learned a lot of ideas that could help math teachers and Physics First teachers in their efforts to teach in their respective subjects. Some things will require making changes from traditional teaching methods, while other ideas will fit in well and improve the learning process. I will start with a few ideas that are easy to use.

Math and Physics teachers can both gain a lot by just using the same terminology. We all talk about similar concepts and ideas, so let's use the same vocabulary and descriptions. Taking this idea even further, we can even work similar problems with the same steps. Math teachers can use some examples from physics that relate abstract concepts to something students understand in real life. This requires some purposeful collaboration between teachers.

In addition to small changes, make attempts to find ways to connect physics and math. The two courses can and will help the other out. It will take a small amount of extra work, and some purposeful collaboration, but it will definitely pay off.

KIM BELANGER, KIRKSVILLE R-3:

The Physics First Academy will be a very well spent week. You will refresh your mathematics skills and gain a new respect for the effort required of the freshman science teachers in your district.

Be prepared to keep track of data and discover equations. Using

the lab equipment to collect data (as opposed to having it handed to you) is a learning experience in itself. It was a great reminder of the effort needed to have the proper equipment out for each group.

The mathematics problems are a fun way to work across the curriculum. It is very easy to see how mathematics and science can be brought together to keep students actively engaged in their educations.

BECKY MCCURDY, COMMUNITY R-6:

When I first learned of my fellow science teacher's involvement with the Physics First program, I thought great, but this doesn't affect me. Then as I learned more about the program and was asked to attend the Math Teachers Academy, I began to worry that this might affect me. After attending the Academy this week, I am positive that my colleague's involvement will affect me, but the emotion is no longer worry, but instead it is excitement!

The science teachers involved in the Physics First program will be incorporating a great deal of mathematics into their classrooms. This is going to require us to be flexible in our classrooms to support them. However, they can be of great as-

sistance to our classes as well. Their programs give some real world application and can provide numerous examples and reinforcement to our instruction. The reinforcement can go both directions.

Don't be afraid to collaborate with your science teacher and get your curricula in order so that you can maximize both your instruction and get the most from your programs!

GARY JONES, GREENFIELD R-4:

I have recently completed the math teacher portion of the Physics First academy conducted at the University of Missouri. This program contained many laboratory exercises, which should help students understand math concepts at the 9th grade level. Math can also help the student better understand physics concepts in a number of ways and methods. Some are standardization in terminology, clarifying definition of slopes, and how slope magnitude is recorded. These are but a few of the areas that can facilitate learning.

The success of the Physics First program can help the student not only in higher physics courses but in higher math courses as well. I look forward to meeting with you to explain the many aspects of this exciting program.

KIM HURST, McDONALD COUNTY R-1:

I would like to advise you to use more formulas. The more comfortable students are with using variables other than x and y , the easier it will be for them to adjust to the formulas in Physics First.

Also teach slope early. They don't need to know how to solve equations to plug in for slope.

Ohm's Law Clock



Finally, collaborate!! Your science teacher wants to help you and you can help them. In time you will see how beneficial the program is to Algebra 1.

TODD BRENDL, LONE JACK C-6:

I teach 7th-9th grade math in my district. I have seen the importance of vocabulary in both math and physics and know that I need to interchange terms in my classroom so students are familiar with terminology. When solving for variables in Algebra, I will begin using Physics formulas as part of my examples. This will demonstrate their knowledge of solving for variables for me and reinforcing formulas for the physics classroom. The x- and y-axis don't have to be labeled x and y and it would be helpful to randomly pick other letters like t (for time) and v (for velocity) to use at different times. Find out what math ideas the Physics teachers are going to cover and try to overlap some of the ideas at the same general time. The two programs can complement each other if you will work with your science teacher.

DENISE CORIO, GRANDVIEW R-2:

I have just completed the Physics First Academy for math teachers and have some suggestions for you.

First, your science teacher is your teammate, not your foe. He/She will be using many of the concepts you will be teaching. You can reinforce each other's lessons. For example, they use the concept of slope in their force and motion unit.

Second, be flexible. Scientists do not always label their axes as x and y. They label them according to what they represent (as we

SHOULD). You will find they may label the horizontal axis as t (for time) and the vertical axis as x (for displacement).

Finally, be positive! This is a new program for all of us. If you remember my first two suggestions, the program will reap benefits for our math AND Science students.

Color of tube	Slope	y intercept	Slope	y intercept	Slope	y intercept	Slope
Blue	4.5 cm/s	10.7 cm	4.3 cm/s	9.1 cm	4.16 cm/s	14.09 cm	3.9 cm/sec
Purple	4.55 cm/s	14.5 cm	5.1 cm/s	8.7 cm			
Red	8.93 cm/s	12 cm	7 cm/s	11.5 cm	7.13 cm/sec	19 cm	
Yellow					6.7 cm/s	18 cm	7.14 cm/s
Orange	7.1 cm/s	12.5 cm	6.9 cm/s	8.9 cm	6.56 cm/s	22.2 cm	7 cm/s
Green	4.15 cm/sec	10 cm			3.75 cm/s	12 cm	4.25 cm/s

Slopes obtained from the bubble tube lab

BRENT BURTON, SPRINGFIELD R-12:

Information to collaborate with your Physics First teacher.

1. Both teachers can use similar language for same subject.
2. Units (use them when solving equations, as applicable)
3. Align dates when certain subjects (i.e. equations) are taught
4. Graphs (labels, slopes, axes, etc.)
5. Specific mathematical operations (Clear up w/ teachers) for example, show the distributive property in equations such as
6. Introduce subscripts to students.

JULIE COFFEY, NORTH KANSAS CITY:

Next year you will have a colleague in your building teach-

ing the Physics First curriculum. Many concepts from Algebra are taught in the Physics First curriculum as well. If you work with your physics teacher you can create an ideal situation in which ideas, concepts, and vocabulary are repeated and reinforced in both courses. Also, you may find that using examples from the Physics First curriculum in your Algebra class just might answer the age-old "When will we ever need this?" question. Finally, if you are interested in broadening the problem solving skills of your students or increasing the DOK of your question then the Physics First curriculum should prove helpful.

ANGELA CAMILLO, KINGSTON K-14:

There are some issues that you need to consider as you are teaching Algebra students who are also enrolled in Physics First. I would highly recommend that you spend some time collaborating with the science department. It will not be the goal of the Math department to teach the Physics curriculum, but to look at how the Science and Math can complement each other. There are many topics that overlap in the Math and Science curricula that you need to consider how they are addressed by both departments. The Math and Science departments both need to address the similarities and differences in the concepts. For example, slope is addressed in different ways by each subject. Math and science teachers need to be aware of these differences so they can be addressed to students. By working with your Physics teacher to address how these concepts are taught in both classes will help provide a better understanding for the teachers & students in the long

run. Collaboration with the Physics First teacher is not asking for you to do more work, but to expand your knowledge of the math concepts used in other areas.

ERIN KING, FERGUSON-FLORIS-SANT:

As you prepare for your upcoming year of Algebra 1, here are a few things to keep in mind:

The 9th grade science students will be embarking upon a year of physics. This should be an exciting year for math and science education because Algebra 1 and Physics are so related. The main thing to remember is that physics and algebra have slightly different notations for the same concepts (i.e. graphing, writing equations, slope, etc).

These differences should be no big deal since I went to the summer Physics First academy this summer.

Let's get together during our first PLC meeting to discuss what the differences are and how we as math teachers can help the physics program. Synchronizing our notation & vocabulary will help improve our own classes! Do you remember when kids came to class and said that their science teacher did Δx on top for slope? They weren't lying! Let's meet soon!

It's going to be a great year!

YANCY CODY, COOPER CO. R-4:

My best advice for you is to be open minded and collaborate closely with your Physics First teacher. Remember we as teachers are here to help students learn, so we should do the little extra things to make learning easier for them. In graphing lines it doesn't always have to be x and y axes and since in physics the axis are switched we should say independent and dependent

variables. Also let them use the data they've collected from a lab to teach them how to plot points, because this will help them to understand why graphing is important.

In closing I hope you give this program a chance and encourage your students to do the best they can in this program. It involves a lot of math that students will struggle with and we need to be there to help them along the way. So try to stay on the same page as your Physics First teacher.

LINDSEY WENGER, MORGAN COUNTY R-2:

This has been an enlightening week. There are aspects of math that I have taught that I never would have thought about needing to "re-vamp." For example, I used to teach the slope formula very strongly: $(y_2 - y_1) / (x_2 - x_1)$. After this week and seeing the differences in Physics First I will not stress this anymore. Instead I will discuss slope as the vertical change over the horizontal change.

There are many areas that can be tweaked to make Physics First and mathematics flow together better, but I think the number one most

important piece of information I am taking away from this conference is the need for collaboration. I think it will be imperative for the math and science teachers to have a time set aside to discuss what concepts are overlapping and how they should be presented or discussed in class.

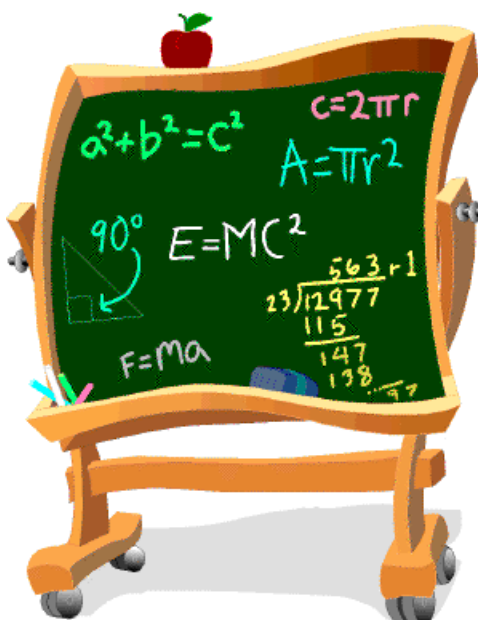
UNSIGNED:

I would like to strongly encourage you to sit down with your Physics First teachers and start a conversation. Physics First will have a lot of concepts that will help your students understand math better. Knowing what labs they do and how they use slope can help you explain the same concepts in math class better. If nothing else in the first year, both teachers should know the notation and vocabulary used in both math and science. Without the awareness of vocabulary there could be a huge disconnect for kids, but by being aware of this issue both teachers can support each other and make the understanding stronger for the student.

As a math teacher you can help support your physics teachers by working with different variables other than x and y and by using the formulas they will see in that class for solving for a variable and evaluating problems in your class.

UNSIGNED:

This was a week of learning and observing. I had the opportunity to observe the science teachers work on their Physics First class. Seeing them perform experiments and discuss the material was very enlightening. It helped me make more connections between physics and algebra. My advice to you is to take the time to not only talk with the Physics First teachers at your school but also really listen to what



they have to say. I think you will find there are many ways you can help each other through vocabulary, examples and just simple reminders of what they have seen in not only their physics class but also in their algebra class.

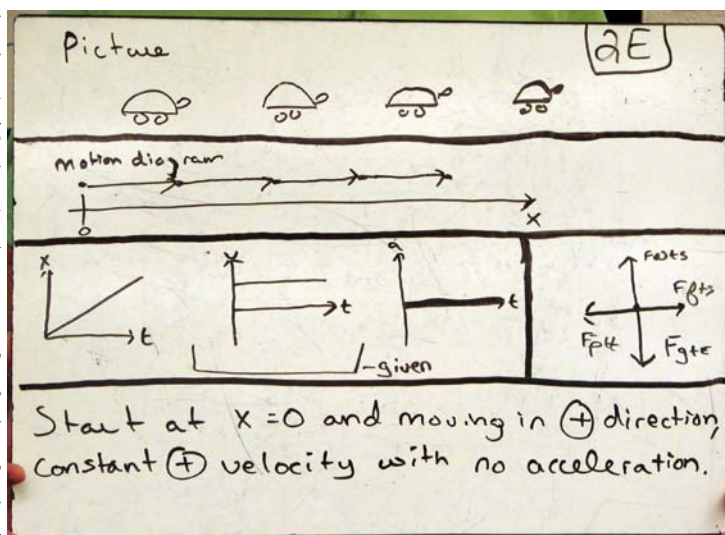
UNSIGNED:

After attending the Physics First Academy, I have gained useful information that I would like to share. I will be working with my Physics First teacher during PLC time to exchange ideas and information. I found that I really needed to have conversations with my classes/students about how the axes on which we plot independent and dependent variables can be interchanged based on what is being measured/graphed. Another problem that I found was that the two curricula were not aligned very well, which caused confusion. By having conversations with your fellow Physics First instructors, you may be able to combat problems before they start. A common misunderstanding is labeling axis and using slope. Physics uses different letter variables to label graphs, while mathematics typically uses x and y . One conversation that occurred was for mathematics instructors to use different letters/symbols to label axis. In a second conversation, we were told to ALWAYS make sure students include units of measure. I will be making small changes in class discussion, and possibly team teaching with my Physics First teacher.

I hope this gives you a basic idea of how we can aid student learning for algebra and Physics First.

UNSIGNED:

Attending the Physics First academy is beneficial for all math teachers. While at this academy a teacher is able to gain the understanding of a variety of techniques that physics teachers use in their class. The hands-on experiments are very interesting and a math teacher could use the ideas behind the experiments as a real-life tool within their class. The conference is also beneficial for the communication you gain with your physics teacher in your district. Something we focused on was the vocabulary differences and similarities.



Whiteboard of pictorial, graphical and verbal representation of uniform motion

We worked on reaching a common ground on particular language we want to both cover that would clear up confusions in both classes. Lastly, we talked about pacing and topics covered that help both classes. We all felt that if we continued to work together we would be able to increase the level/depth of knowledge in all math and science classes.

UNSIGNED:

After attending the Physics First academy, there are small changes we can make in our class-

rooms that will help the Physics First teachers in our district.

Most of the changes are in how we approach concepts. Since $x(t)$ is the vertical axis in the PF class, then perhaps we need to get rid of the "horizontal is always x and vertical is always y " way of graphing. We can talk about independent and dependent axis or name them other things besides x and y . Instead of always finding slope with an equation, we need to look at it as a change in rise over change in run. We can use subscripts more and have the students verbalize concepts more often.

I think it's important that we collaborate and support our Physics First coworkers by meeting with them and talking to them about coordinating our approaches and terminology. We must do what's best for the kids.

Stand together or we will hang separately.

UNSIGNED:

It is important to be open to thinking about our methods & procedures in a different way. You will not

have to change everything you do. Open communication between you and your PF colleagues will be important. You are not teaching PF and they are not teaching your Algebra class. Instead, you are supporting each other to help your students to be successful in both classes. Talk to the PF teachers about what math concepts are important. Then figure out how you can incorporate some PF notation or concepts into your current curriculum. Also, discuss verbiage that is used in both math and PF classes. Try to be consistent in both classes when teaching the

same concepts to reduce your students' confusion and misconceptions. Take time to clarify what vocabulary is important for the PF teachers. For example, a horizontal line has zero slope, not no slope. If you and your PF teachers work together, students will benefit!

UNSIGNED:

Physics First is an exciting program to participate in and observe. There are so many ways that the Physics First program overlaps with our math curriculum and I am excited to see how student performance is affected.

I do not expect to make major changes to my curriculum. Instead, my adjustments will be small. Really, I think I will gain an appreciation for what is going on in the Physics First classroom and be able to answer questions or clear up student misconceptions. Enjoy the collaboration.

UNSIGNED:

Physics First is a program I was attended this summer that informed me about the relation between Physics and Algebra 1. My 9th grade science teacher was able to come for a month to learn the entire curriculum. A few things I noticed that us as math teachers can do to help the Physics First science teacher are:

1. Use independent and dependent to label the x and y axis, because in physics the y-axis is called the x. "x" stands for position.
2. Make sure to include units when solving problems.
3. Use physics formulas for substitution lessons so students are more familiar with them.

There are so many more things we can do, but collaborating with your science teacher will make the process much easier!

UNSIGNED:

It would be my suggestion to meet with your Physics First teacher and iron out the vocabulary, formulas, and topics that will be discussed throughout the year. It is important to get a consistent vocabulary and to use similar variables in both classes. Make sure to cov-

er similar material at an appropriate time so that the ideas from Physics First and math classrooms reinforce each other. You don't need to change your curriculum, just modify it to support Physics First. With proper collaboration both science and math departments in your district can benefit from the program.

Willow Springs High School Physics First teacher Kevin Hummel takes data for a uniform motion experiment with the math teacher from his school, Sarah Doss. Sarah's letter is on page 3.



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