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> You cannot teach a man anything; you can only help him discover it in himself.
>
> -- Galileo Galilei

WHY DON'T WE USE WHAT WE TEACH? USING GRAPHS TO SOLVE ONE-DIMENSIONAL KINEMATICS PROBLEMS

by Scott Schultz
Delta College

Of all the teaching strategies that physics education research has promoted over the years, one of the most highly adopted has been the use of microcomputer-based labs (MBL). MBL has captured the hearts of physics instructors, and the motion detector (sonic ranger) is the probe most widely used.

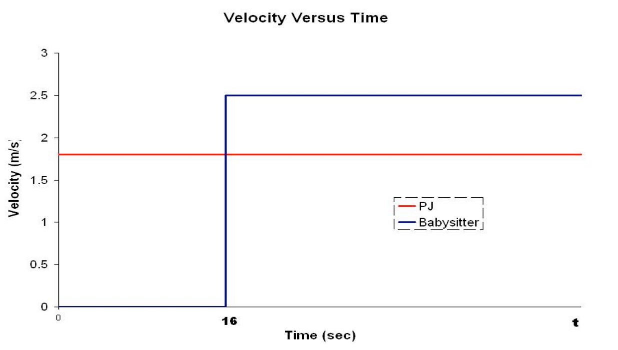
As at other institutions, my students perform experiments and examine real-time position versus time, velocity versus time, and acceleration versus time graphs. Through a series of conversations with their peers and a set of probing questions, students develop a working framework for the concepts of position, velocity, and acceleration and the relationships between them. Building connections graphs and these experiments seems to be the key to the success of these MBL experiments. But, just when we think that our students are beginning to gain a conceptual foothold on these basic kinematics concepts, instructors all too often abandon the graphs in favor of a traditional approach to solving problems that involves using constant acceleration.

Through my participation in an ISLE workshop session led by Dwain Desbien, I now use graphs for solving problems. I find that graphs not only are useful for students to gain a more visual understanding of kinematics, but also are useful for solving the same one-dimensional problems traditionally. Many times the solutions using graphs are more straightforward and understandable than using the equations. This method also makes a connection between the HW and the lab, reinforcing the importance of the activity.

Here is one example:

To earn extra cash, or maybe brownie points, you agree to baby-sit my kids. PJ can run at a speed of 1.80 m/s, while you can run at 2.50 m/s. PJ runs by you and you notice he isn't stopping and is running straight for a busy road. Despite your pleas for him to stop he keeps running. If PJ has a 16.0 second head start, how long will it take you to catch him and how far will you need to run?

This problem can be solved using either a position versus time graph or a velocity versus time graph. By the end of the MBL experiment using the sonic ranger we would expect our students to be able to draw either graph. The following is the velocity versus time graph.



The distance traveled is the area under the curve. The area of PJ's graph is a simple rectangle of area 1.8t. The babysitter's graph is a rectangle of height 2.5 and length (t-16), giving an area of 2.5(t-16). Setting the two areas equal, 1.8t=2.5(t-16), and solving for t yields t=57.1 sec. Using this time, the area of either rectangle can be calculated as 103 m. Since the babysitter didn't run the first 16 seconds, we subtract off 16 to find the time the babysitter ran is 41.1 sec.

The best way to understand the usefulness of this approach is to try it in class and see how the students respond to it.

sfschult@delta.edu

> The capacity to learn is a gift;
> The ability to learn is a skill;
> The willingness to learn is a choice.
> -- Dune: House Harknonnen,
> p. 437

TOOLS FOR INTRODUCTORY PHYSICS MOTION DIAGRAMS

by Tom O'Kuma

Lee College

Introduction

I have found the use of motion diagrams to be very useful in my conceptual, college and engineering physics courses. The form of motion diagrams that I use was developed by Alan Van Heuvelen in the late 1980s as part of his Overview Case Study approach[1,2] to teaching introductory physics. I started using motion diagrams in 1989 after I saw Alan Van Heuvelen introduce them at an IUPP Conference in Denver[3]. Originally designed for the calculus-based course, I modified the motion diagrams for my algebra-trigonometry based physics students in 1990 and conceptual physics students in 1994. I have been modifying them since for better use with my physics students. In this article, I will first introduce the one-dimensional form of the motion diagram, then the two-dimensional form (which can also be used for 1-D problems), and finally the rotational motion form. At the end, I will introduce a different type of motion diagram used by Paul D'Alessandris in his Spiral Physics curriculum[4].

One-Dimensional Motion Diagram

A motion diagram represents the position, velocity, and acceleration of an object at several consecutive times. It is like a video of the motion played back frame by frame. The frames are usually separated into equal, successive time intervals. At each position, the object's velocity and acceleration are represented by arrows. If the acceleration is constant throughout the motion, one arrow can represent the acceleration at all positions shown on the diagram. We usually draw motion diagrams of constant acceleration or regions of constant acceleration.

Procedure:

To draw a motion diagram, you sketch 3 to 5 consecutive "frames" of the position of the object. You start by drawing the actual object at some initial position. Then, you draw a second object at its next position (next frame). For example, if the object is moving to the right, then the next position is to the right. How far it is placed to the right depends on how fast the object is moving – greater separation of the two objects if the object is moving fast, smaller separation of the two objects if the object is moving slow. You should follow this same approach for the next 2 to 4 frames.

To draw the velocity "arrows", look at the separation between two consecutive objects (this is the rate of change of position) and draw the length of the velocity arrow (called the velocity magnitude or speed) based on the position separation. The direction of the velocity arrow is in the direction that the object is moving. We locate the velocity arrow usually below the drawn object at the same location below the drawn object.

To draw the acceleration "arrow" (only one arrow for constant acceleration motion diagrams), look at the separation between the velocity arrows (this is the rate of change of velocity). If the velocity arrows are not changing length and direction, then the acceleration is zero. If the velocity arrows are getting longer, then the acceleration is some constant in the same direction as the velocity arrows. If the velocity arrows are getting shorter, then the acceleration is some constant in the opposite direction to the velocity arrows.

Motion Diagrams

The motion diagrams for three common types of linear motion are described below.

Constant Velocity: The first motion diagram, shown in Figure 1, is for an object moving at a constant speed toward the right. The motion diagram might represent the changing position of a car moving at constant speed along a straight highway. Each object (car) indicates the position of the object at a different time. The objects are separated by equal time intervals. Because the object moves at a constant speed, the displacements from one object to the next are of equal length. The velocity of the object at each position is represented by an arrow with the symbol v under it. The velocity arrows are of equal length (the velocity is constant) and in the same direction. The acceleration is zero because the velocity does not change.

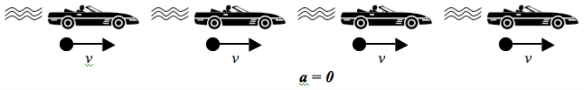


Figure 1. The motion diagram for an object moving with a constant velocity. The acceleration is zero because the velocity is not changing.

Constant Acceleration in the Direction of Motion: The motion diagram in Figure 2 represents an object that undergoes constant acceleration toward the right in the same direction as the initial velocity. This occurs when your car accelerates to pass another car or when a race car accelerates (speeds up) while traveling along the track. Once again, the objects (cars) represent schematically the positions of the object at times separated by equal time intervals Δt. Because the object accelerates toward the right, its velocity arrows increase in length toward the right as time passes. The product $a(\Delta t) = \Delta v$ represents the increase in length (the increase in speed) of the velocity arrow in each time interval Δt. The displacement between adjacent positions increases as the object moves right because the object moves faster as it travels right.

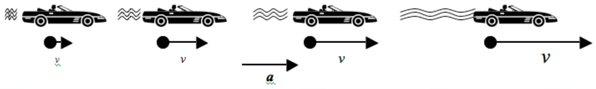


Figure 2. A motion diagram for an object that is accelerating in the direction of its velocity. The velocity increases as time progresses.

The direction of the acceleration arrow is in the same direction as the velocity arrows since the speed is increasing.

Constant Acceleration Opposite the Direction of Motion: The motion diagram in Figure 3 represents an object that undergoes constant acceleration opposite the direction of the initial velocity (this is sometimes called deceleration - a slowing of the motion). For this case, the acceleration arrow points left, opposite the direction of motion. This type of motion occurs when a car skids to a stop. The objects (cars) represent schematically the positions of the object at equal time intervals. Because the acceleration points left opposite the motion, the object's velocity arrows decrease by the same amount from one position to the next. We are now subtracting $\Delta v = a(\Delta t)$ from the velocity during each time interval Δt.. Because the object moves slower as it travels right, the displacement between adjacent positions decreases as the object moves right.

This implies that the acceleration is in the opposite direction to the direction of the velocity.

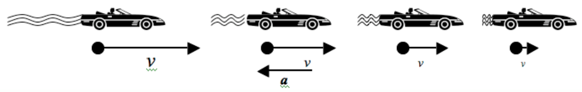


Figure 3. A motion diagram for an object whose acceleration points opposite the velocity. The magnitude of the velocity decreases as time progresses.

How I Use Them

After initially discussion the ideas of kinematics, I use motion diagrams to get students to understand the relationship among the kinematics quantities and to determine if there is an acceleration and if so, its direction. The conceptual development is broken up into four parts. The first part is individual and group work on drawing motion diagrams of objects moving horizontally, vertically, and on inclines – see Motion_Diagram.pdf file[5] on our webpage. In class we usually do #1a, 1b, 2a, 2c and 3. The rest of the packet is then assigned as homework. The second part is a lecture demonstration using an air track and glider to show the various possibilities of linear motion. Students have to draw a motion diagram of what they observed and discuss that as a class – see AirGlider_Interactive_Lecture_Demonstration.pdf file[5]. The third part is individual and group work on drawing additional motion diagrams, including some that have multiple regions of constant acceleration – see Motion_Diagram2.pdf file[5]. The fourth part is done as part of a MBL lab activity. As part of the lab activity, students have to draw motion diagrams of the possible acceleration for a cart moving on a horizontal track. Using a motion detector, they can then detect the motion of the cart and compare their predictions with the motion graphs generated by the cart's motion.

This conceptual development will usually be done over 2 class periods (and 2 lab periods for the MBL lab activity). I have found that motion diagrams help students understand kinematics relationships well. It gives them a way of visualizing the motion and the kinematics quantities together. I also use motion diagrams when I get to forces to link the net force and acceleration. Later when we go into numerical problem solving (not part of my conceptual physics course), we use motion diagrams as part of the "physical representation" (part of the multiple representation problem solving process[1]).

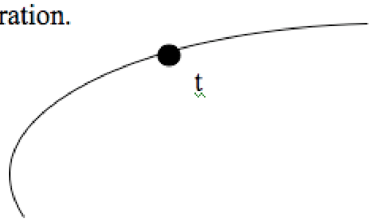
Two-Dimensional Motion Diagrams

There is another type of motion diagram that is, in many ways, more versatile than the original type of motion diagram. This new type of motion diagram[6], which is sometimes called motion diagram 2, can be used for motion in more than one-dimension and for linear motion. This motion diagram 2 is sometimes called "finding acceleration from known velocities" or "finding acceleration by subtracting velocity vectors".

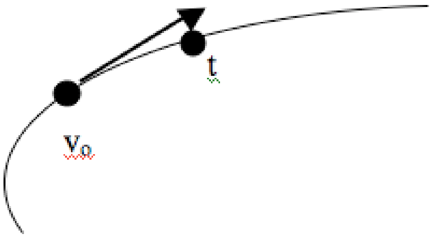
We know that a motion diagram can represent the position, velocity, and acceleration of an object at several different times. In this type of motion diagram, you will be able to find the direction of an object's acceleration at some selected time t. The direction of the acceleration can be determined if we know the objects velocity at two different times separated by a short time interval Δt. We will draw motion diagrams of constant acceleration or regions of constant acceleration.

Procedure:

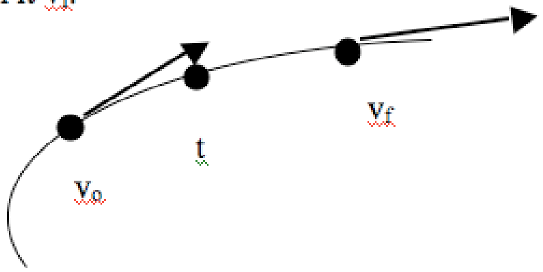
To draw a motion diagram using this technique, you want to first sketch the path of the object's motion. On the object's path, choose the point for some time t at which you want to determine the direction of the acceleration.



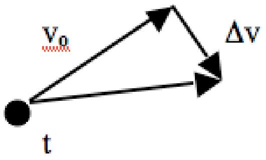
Now, choose a point a little **before** the selecte
original velocity or initial velocity. At this earl
velocity of the object at this point. Note: that the
We will call this the original velocity and label it



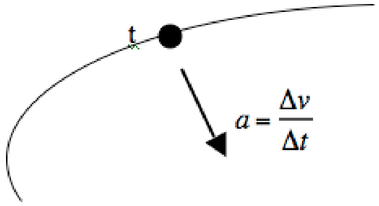
Now, choose a point a little **after** the selected point of time t. This will be known a **the later velocity or final velocity.** At this later point, draw an arrow to represent the velocity of the object at this point. Note that the velocity will be tangent to the path at this point. We will call this the final velocity and label it v_f.



Now, you need to find the change in velocity for the object between the initial velocity and the final velocity. This is known as the **change in velocity** and will represent the velocity change for the object at time t. To find the change in velocity Δv during the time interval Δt, place the tails of the v_0 and v_f together. The change in velocity is a vector that points from the head of v_0 to the head of v_f. Notice in the figure that $v_0 + \Delta v = v_f$ or rearranging, $\Delta v = v_f - v_0$ (that is, Δv is the change in velocity).



Finally, the direction of the acceleration is always in the same direction as the velocity change. The acceleration equals the velocity change Δv divided by the time interval Δt needed for that change; that is, $a = \Delta v/\Delta t$. If you do not know the time interval, you can at least determine the direction of the acceleration because it points in the same direction as Δv.



In summary, notice that the direction of the acceleration is towards the "inside" of the trajectory.

How I Use Them

I use the motion diagram 2 technique to help students visualize the direction of the acceleration (and hence the net force). The conceptual development is done in three parts. The first part is individual and group work on drawing the direction of the acceleration using the motion diagram 2 technique for objects moving along projectile trajectories, curved surfaces, and circular/elliptical paths. – see Motion_Diagram_2D.doc[7]. In class, we usually do #1, 3a, 3c,4a & 5. The rest of the packet is then assigned as homework. The second part is applying this technique (along with force diagrams) to projectile motion and circular motion – see 2D_ProjectileMotion.pdf and 2D_CircularMotion.pdf files[7]. Some of these are done as in-class group work and the rest assigned as homework. The third part is done as part of laboratory activities (some are MBL activities) where they use motion diagrams to interpret and explain their observations. In one type of lab activity, the students take video data of 2D motion, analyze the data, and then compare their predictions with the video analysis and motion graphs.

This conceptual development will usually be done over 2 class periods (and 2 lab periods for the lab activities). I have found that students can find the direction of the acceleration using this technique and then can use that with Newton's Second Law to help solve problems conceptually and later numerically.

Rotational Motion Diagrams

A rotational motion diagram represents the angular position, velocity, and acceleration of a rigid body at several consecutive times. We use a disk to represent the rigid body and assume that counter-clockwise rotation is positive. In this type of motion diagam[8], we use a disk to represent the angular position, θ, and change in angular position, Δθ. We use separate disks to represent the change in angular position with the angular velocity, ω. By looking at the change in the angular velocity, we can determine the direction of the angular acceleration, α.

Procedure and Rotation Motion Diagrams

Rotation at Constant Angular Velocity: The motion diagram in Figure 4 represents a rigid body that rotates in the xy plane in the counterclockwise direction at constant angular velocity (it has a positive angular velocity in the z direction perpendicular to and out of the paper). The dots represent the changing position of one point on the rotating body at times separated by equal time intervals. Notice that equal distances separate adjacent dots. Also, the change in the angular position Δθ between adjacent dots is the same [constant angular velocity (ω = Δθ/Δt)]. At the side of the axis view motion diagram are three perspective views of the position of the dot at the three different times. Notice that the angular velocity vector points up perpendicular to the plane of the motion and does not change. Because ω is constant, the angular acceleration vector is zero.

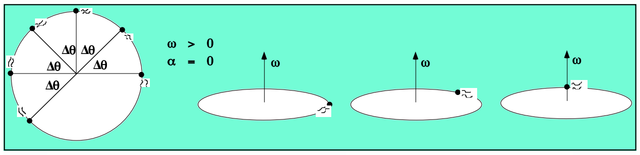


Figure 4. A motion diagram for a rigid body that rotates at constant angular velocity counter-clockwise. The angular acceleration is zero because the angular velocity does not change.

Rotation at Increasing Angular Velocity: The motion diagram shown in Figure 5 represents a rigid body that rotates with increasing angular velocity in the counterclockwise direction. This rotational motion is the analog of the situation involving linear motion in which a car's velocity increases - its acceleration points in the direction of the increasing velocity. The dots below and to the left represent the changing position of one point on the rotating body at times separated by equal time intervals. Notice that the distances between adjacent dots increase as it moves around the circle. Also, note that the change in the angular position $\Delta\theta$ between adjacent dots increases - the rigid body rotates at increasing angular velocity. At the side of the axis view motion diagram are three perspective views of the position of the dot at three different times. The angular velocity vector ω points up perpendicular to the plane of the motion and increases in length as the object rotates faster. Because ω increases in the upward direction, the angular acceleration vector α points up.

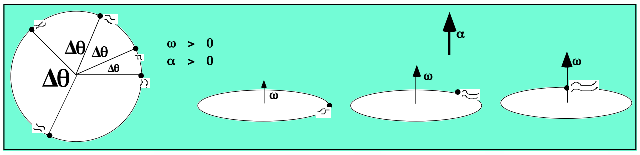


Figure 5. The motion diagram for a rigid body whose angular is increasing. The angular acceleration is in the direction of the increasing of the increasing angular velocity.

Rotation at Decreasing Angular Velocity: The motion diagram shown in Figure 6 represents a rigid body that rotates with decreasing angular velocity in the counterclockwise direction. This rotational motion is the analog of the situation involving linear motion in which a car's velocity in the positive direction decreases its acceleration points opposite the velocity. The dots below and to the left represent the changing position of one point on the rotating body at times separated by equal time intervals. Notice that the distances between adjacent dots decrease as it moves around the circle. Also, note that the change in the angular position $\Delta\theta$ between adjacent dots decreases - the extended body rotates at decreasing angular velocity. Beside the axis view motion diagram are three perspective views of the position of the dot at three different times shown in the motion diagram. The angular velocity vector points up perpendicular to the plane of the motion and decreases in length as the object rotates slower. Because the angular velocity ω decreases in the upward direction, the angular acceleration vector α points down in the negative direction.

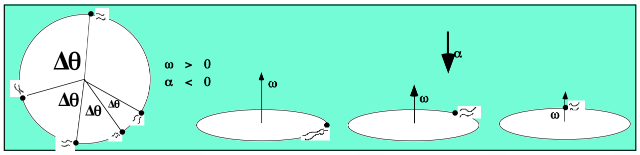


Figure 6. The motion diagram for a rigid body whose angular velocity ω is decreasing. The angular acceleration α points opposite the direction of the decreasing angular velocity.

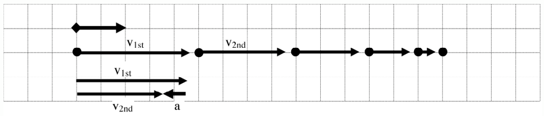
How I Use Them

I use the rotation motion diagrams to help students visualize what direction the angular acceleration is in (and later the direction of the net torque). I do the conceptual development in two parts. The first part is individual and group work to develop this technique – see Rotation_Motion_Diagram.pdf[9]. In class, we usually do #1 and 3 with the rest of the packet assigned as homework. The

second part is done as part of laboratory activities (most are MBL activities) where they use the rotational motion diagram to predict results and interpret their observations. This conceptual development is done during 1 class period (and parts of several lab periods).

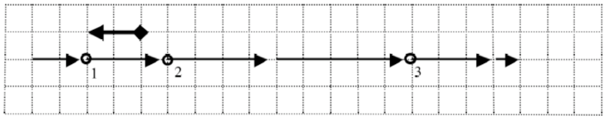
Motion Diagrams in Spiral Physics

In the early to mid 1990s, Paul D’Alessandris (Monroe Community College, Rochester, N) developed a new curricular approach, known as Spiral Physics[10], with a modified form of the motion diagram. In Spiral Physics motion diagrams, the physical representation of the object is replaced with a dot. Additionally, the location of the origin and the positive direction is placed on the motion diagram. The velocity arrow goes from one position (dot) to the next position. The acceleration is found by subtracting the 2nd velocity from the 1st velocity. A one-dimension motion diagram is shown below. Notice that the arrow at the top of the diagram shows the “origin” and indicates the positive direction. This approach allows you to easily move around the location of the “origin” and the positive direction.



In Spiral Physics, this allows you to generate motion diagrams that have multiple regions of constant acceleration with the placement of the origin and the positive direction anyway you feel will get students to better understand kinematics. Additionally, you can couple the motion diagram with additional qualitative tasks, such as the example below.

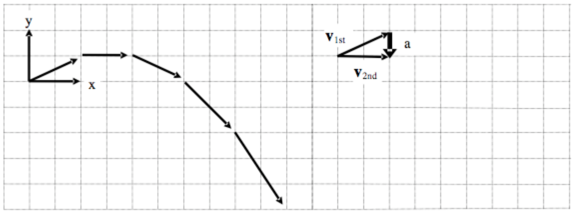
For the motion diagrams below, determine the algebraic sign (+, - or zero) of the position, velocity, and acceleration of the object at the location of the three open circles. Describe an actual motion that could be represented by each motion diagram.



	1	2	3	Description:
r				
v				
a				

Another powerful conceptual approach that is used in Spiral Physics is to couple the motion diagram with the motion graphs for the same motion. By going from the motion diagram to the motion graphs and vice-versa, a more robust understanding of kinematics is developed.

In Spiral Physics, two-dimensional motion is a modification of the previously mentioned two-dimensional motion diagrams. It also includes the “origin” and coordinate system explicitly placed on the diagram. Again, these motion diagrams can be “linked” to other qualitative tasks, including motion graphs. In his Model II section of Spiral Physics, Paul D’Alessandris states that:



> **“Motion Diagrams are of crucial importance in investigating scenarios involving *multi-dimensional motion.*”[10]**

In Spiral Physics, the motion diagram is one of the important steps in doing numerical problems solving as well.

Summary

Motion diagrams are valuable conceptual tools that help students build a more robust understanding of kinematics. Regardless of which motion diagram you choose to use and how you use them in your instruction, I think you will find them to be very useful.

References

[1] Alan Van Heuvelen, "Overview, Case Study Physics", American Journal of Physics, 59 (10), 898-907 (1991).

[2] Arthur V. Farmer, "A new approach to physics teaching, The Physics Teacher, 23, 338-343 (1985).

[3] John S. Rigden, Donald F. Holcomb, and Rosanne DiStefano, "The Introductory University Physics Project", Physics Today, 46 (4), 32-37 (1993). Tom O'Kuma, "Introductory Physics Reform", CaFD Newsletter, Fall 1996, 2-3.

[4] Paul D'Alessandris, "Spiral Physics Active Learning", CaFD Newsletter, Spring 2007, 15-19.

Paul D'Alessandris, "Implementing an Active Learning Environment in Introductory Physics", CaFD Newsletter, Spring 2007, 11-13.

[5] Go to http://www.physicsworkshops.org, then click on "Tools for Introductory Physics", then "Motion Diagrams", then "1-D Motion Diagrams", then "Conceptual Tools", and then the file.

[6] Alan Van Heuvelen, "Overview Case Study Physics Study Guide", McNeill-Hayden Publishers, MI. Chapter 1.

[7] Go to http://www.physicsworkshops.org, then click on "Tools for Introductory Physics", then "Motion Diagrams", then "2-D Motion Diagrams", then "Conceptual Tools", and then the file.

[8] Alan Van Heuvelen, "Overview Case Study Physics Study Guide", McNeill-Hayden Publishers, MI. Chapter 6. Alan Van Heuvelen, "Active Learning Problems Sheets", McNeill-Hayden Publishers, MI. Chapter 5.

[9] Go to http://www.physicsworkshops.org, then click on "Tools for Introductory Physics", then "Motion Diagrams", then "Rotational Motion Diagrams", then "Conceptual Tools", and then the file.

[10] To obtain more information about Spiral Physics, contact Paul D'Alessandris at pdalessandris@monroecc.edu.

tokuma@Lee.Edu

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2009 Summer Meeting,
Ann Arbor, MI
July 25-29, 2009

LEARNING, EVER LEARNING ABOUT INSTRUCTIONAL STRATEGIES IN INTRODUCTORY PHYSICS WORKSHOP REFLECTION

by Kathy Hockman
Randolph Union High School

I flew to Houston, Texas last November for a multitude reasons, the most important being to learn something new about how to inspire students to want to learn physics. Did you notice that I did not say to learn how to teach it? That's because, while I do want to continue to improve as an instructor, what I really want for "job satisfaction" is that I improve enough so that my students want to learn more. More about themselves as learners and citizens, more about the world we live in and how it works, and more about the need to keep learning because one thing that never changes is that everything changes.

As is always the case when I attend a workshop that I chose to attend in my perpetual pursuit of professional (and personal) development, as opposed to some we are "offered" on teacher "work" days (as if we do not work the 175 days?!), I was excited. I am a life long learner and hope never to see the day when I think I know it all. I am especially excited when I attend a workshop put on by the Physics Workshops gang because I know that I will learn every minute of every hour that we are together, whether in the van between stops, the classrooms, or work groups. Even sometimes during the optional open discussions in the evening, though we try to steer clear of physics talk then.

The workshop that I flew to Texas for was on Instructional Strategies in Introductory Physics. Yes, the title says instructional strategies, but that is a clever way to mask the real "meat" of the program which is to get students to engage in the learning process, thereby lessening the load on the instructor's shoulders to keep the one-sided conversations going and improving students' conceptual understanding of the content. As participants in this workshop, we were actively participating from the get go. Interactive engagement was our first topic and as a form of modeling the instruction, our introduction to the idea was interactive. Give and take, checking with your students, having them check with each other, and you throughout the learning process is a better way to ensure the stability of the constructs we are building for our students to take with them.

Our next topic was getting down to the bare bones of why some students may not have a deep knowledge base or the tenacity required for problem solving. Students need to process information, get down and roll around in it, if you will, to be able to see it from different perspectives so they can recognize it from various angles. With this experience they confirm or reform preconceptions, and build a better foundation for the learning that is yet to come. One of the ways to help students with this interaction is through modeling discourse, which is a more detailed approach than I dare outline here, but the basics are fairly universal, even if we tend to forget them over time.

One of the advantages of modeling discourse and other forms of cooperative learning is that there is an intentional formation of an interactive learning community. There is also an inherent dissipation in the need for classroom discipline because the shift is towards classroom management. Everyone has a role

and if everyone is fulfilling their role, there is no time spent on behavior issues. We can all list many reasons behind the different behaviors that we have to work with in any given class, but lack of engagement in the work being done is probably at the top of the list.

By intentionally setting the scene to be an ongoing set of clips (individual class meetings) that add to form the overall film (the entire course outline) instead of disjointed lectures, labs, or chapters, keeps the students learning from one day to the next and helps to alleviate the need for re-booting their memories every time you get together. Depending on the schedule your school operates under, block scheduling, for example, it may be 4-5 days between class meetings. With the students engaged and following their minds to the different conclusions that scientists can come to for the same discussion allows them to internalize both the process and the reward. You will find them still discussing class topics in the lunchroom, study halls, and even the senior lounge.

In addition to the excitement from this workshop is the inevitable impatience of having to wait to use the neat ideas and tools that we are given. I had been warned that some, if not most, of the strategies would best be incorporated at the start of the year or a new semester. But I tried a few anyway. White boarding was an obvious first choice, both financially and physically, for immediate inclusion and worked well once students accepted that they could in fact be assessed based on work they did, but did not hand in!

White boarding is a great way to encourage group thinking and problem solving skills, as well as public speaking, presenting ideas, and listening to co-workers. All very important skills for later in their education and the workplace. It also provides the instructor with a way to sit back and immediately assess where the class is in terms of your expectations and where you may need to provide reinforcement.

My students had used white boarding to work through math problems so they were not new to the concept, but they sure flinch when we dare to bring a strategy or skill from one isolated classroom to another. That, in itself, is a great support for working with peers across the curriculum to ensure connections for the students so they do not go on believing that they only need to speak "Algebra" in the math classroom and "Physics" in the science classroom, and so on. Imagine a world where students and people, in general, can see the systems within systems that surround us.

Some of the other strategies are great ideas but hard to incorporate into an already formed and flowing class structure. Students don't take kindly to bumps in the road to their education or feeling out of their comfort zone. For some reason, I can not convince them that the greater the discomfort, the greater their learning. Go Figure! I find the same active resistance to the use of T.I.P.E.R.S. (Tasks Inspired by Physics Education Research) and other thought provoking, outside the box, logical reasoning tasks that I have gathered over the years of workshops based on the current research in Physics Education. Applied pedagogy. Hmmm.

I have great hopes for next year. I think one of the keys to success for students in my classroom is for me to be enthusiastically engaged in their learning process, which means I am learning right alongside of them. With instructional strategies outlined and time to plan around them to incorporate them seam-

lessly, I hope my students will be more willing to forego their attachment to the "Plug 'n Chug" rut they take such comfort in and come out to play in the real world where the answers are always available with interactive engagement and discourse. Giving and taking. Strengthening the foundation of their understanding so that the misconceptions that we all bring to new learning situations can be laid to rest and replaced with valid knowledge.

maineeducator@aol.com

What did you learn participating in a Physics Workshop? How did you incorporate it into your classroom? How has it enhanced learning for your students? PWEN welcomes papers regarding your workshop experiences. In all submissions, please include the paper title and the author's name, school, and e-mail address. Submit workshop papers to Tom O'Kuma (tokuma@lee.edu) and Dwain Desbien (dwaindesbien@estrellamountain.edu).

Find information and apply now for upcoming workshops at www.physicsworkshops.org.

CAPSTONE PROJECTS

by Dwain M Desbien

Estrella Mountain

Community College

My classes are anything but traditional. There is a large emphasis on group work, and discussion among students is vital. As many of you are aware, I don't lecture and students are required to work together as a class to learn physics. I have found this works well for my students and prepares them for future science and engineering courses.

A couple of years ago I began implementing projects in my classes. My classes are not project based like David Weaver's at Chandler-Gilbert CC but rather I use a single project at the end of the semester. The intent of this project is to have the students design, build and describe the physics of project that will require most, if not all, of the physics they have learned throughout the semester. I do these projects in all of my classes but the physics expected varies greatly based on the course (one would expect much better physics from a calculus based course compared to a conceptual physics course). However, just because the physics write-ups may be different, quite often the conceptual physics students projects perform better.

This is not a new idea, to do a capstone project in a class, (and in fact many of the projects are not original at all) it does fit in nicely with the style of my teaching. Some of the projects I have recently done include: building a rocket to launch an egg, building a working telephone, building a trebuchet, building a "city" that is self-contained (energy must be solar, wind...) and building a glider. A picture

of my students testing their trebuchets can be seen below. Also there is a picture of one of the self-contained cities. Each city had to have lights for each house and a water system. This particular city used wind power with a "citrus" power plant for backup. While these projects are not unique to me I do try to add a twist to them. For example the trebuchets had to launch a ping-pong ball as far as possible. However, we launched in a room with a 18 foot high ceiling and along a wall. Thus, the students had to worry about these items as they designed and built. In the picture you can clearly see the wall they had to avoid hitting.

I have been very pleased with the physics the students show and use in building their projects. The quality has been improving year after year as I get better at helping prepare the students to do such projects. I encourage you to consider a capstone project in your class. David Weaver has many wonderful resources for those considering such a project and I am sure he would be more than willing to help you as he has me.

dwain.desbien@estrellamountain.edu

ATE Program for Physics Faculty Update

As of January 1, the ATE Program for Physics Faculty, which is supported by Lee College, Estrella Mountain Community College and the National Science Foundation, has held 11 workshops at 7 different community colleges in 7 states. There have been a total of 245 participants involving 177 different faculty members from 35 states, Puerto Rico and America Samoa.

Of the 124 two-year college (TYC) participants who have attended a workshop, 94 different individuals attended representing 82 different institutions in 30 states. Thirteen different teams of TYC faculty attended workshops. The states with the most attendees are:

California – 14
Texas – 10
Florida – 6

4 states had 4 faculty attendees; 8 states had 3 faculty attendees, 9 states had 2 faculty attendees, and 6 states had 1 faculty attendees.

One TYC faculty member, Faribi Ansari of El Paso Community College, has attended 4 workshops. Four TYC faculty members have attended 3 workshops and nineteen have attended 2 workshops.

Of the 109 high school (HS) participants who have attended a workshop, 75 different individuals attended representing 57 different institutions in 22 states, Puerto Rico, and America Samoa. Eighteen different teams of HS faculty attended workshops. The states with the most attendees are:

Texas – 19
California – 9
Minnesota -7

3 states had 4 faculty attendees; 1 state had 3 faculty attendees, 7 states had 2 attendees, and 8 states had 1 attendee. 1 faculty attendee came from Puerto Rico and 2 came from America Samoa.
Two HS faculty members, Janie Head from Foster High School (TX) and Tommi Holsenbeck from the Science in Motion program at Alabama State University, have attended 5 workshops. Six HS faculty members have attended 3 workshops and eighteen have attended 2 workshops.

Eight other physics faculty members have attended the workshops, including Lila Adair and Harvey Leff, both Presidents of the American Association of Physics Teachers. The Executive Officer of AAPT also attended one of the workshops. Four members of the Science in Motion program in Alabama attended one workshop and one university faculty member who teaches pre-service teachers also attended one workshop.

In 2009, the ATE Program for Physics Faculty will be offering a workshop in late April at Estrella Mountain Community College in Arizona, a conference on the Training of Future Teachers of Physics at Green River Community College in Washington, and a follow-up workshop for participants who attended the New Faculty Conference for Two-Year College Physics Faculty at the 2009 AAPT Summer Meeting in Ann Arbor, Michigan. Information concerning these workshops will be posted on the project website at: http://www.physicsworkshops.org.

ATE Program for Physics Faculty Project Supported by Lee College (TX), Estrella Mountain Community College (AZ), and a grant from the Advanced Technological Education Program of the National Science Foundation (NSF #0603272)
http://www.physicsworkshops.org

Ginny Saiki-Desbien, Editor, Buckeye, AZ
gindesbien@cox.net