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Editorial Board

Note from the Editor

Dear colleagues,

It gives me great pleasure to present this first issue of the Proceedings of the SACS-AAPT Meetings to you. I hope that you will find the materials published in this issue interesting and applicable to your classroom instructions.

Our goal is to provide you with an efficient and convenient tool to share your ideas, to report your experiences, successes, and findings.

Please feel free to make comments and suggestions as well as submit your materials to TatianaKrivosheev@mail.clayton.edu.

Sincerely,

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Discovering wanderers: using image processing software to "discover" planets, asteroids and other wanderers

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By combining the power of planetarium and imaging processing software students can take part in the discovery process. A simple laboratory experiment is described which allows students to "discover" objects that move with respect to the background star field. Objects can be found in either star charts generated by planetarium programs or actual astronomical images. The concept of sidereal time is also reinforced by this experiment.

1. INTRODUCTION

Planetarium and image processing software are common place tools in our introductory astronomy classes. By combining the strengths of these tools, we can develop powerful new astronomy laboratory exercises. How often have we heard the inevitable question; "is that a star or a planet?" This seems to come up nearly every time a novice observer begins looking skyward. One student might remember something about stars twinkling, another might try to answer based on the brightness of the object. Here we have a great opportunity to discuss the ecliptic and point out whatever planets might be visible. Besides looking at a chart or knowing the current position of a planet, how do we spot one? What about a comet or an asteroid? We all know that the answer lies in the relative position of the object and how that position changes from night to night. After all, the "πλαν" part of the word "planet" means something that drifts or wanders. One way of answering the star or planet question is to let the students discover the answer for themselves. Depending on the available equipment, you might photograph the object on several nights or employ screen shots from your favorite planetarium software. The intention is to let the students discover the answer by analyzing the motion of the object. For the purpose of this paper, we will create images using Starry Night® [1] and manipulate the images using Photoshop® [2]. The principle is simple and will work with a wide range of products. The

Astronomy Education Committee of the American Association of Physics Teachers maintains a website that lists free image processing software packages[3]. If you intend to use any of those programs be sure that there is a tool that allows you to subtract of find the difference between two images. There are several free open source planetarium programs available that can be used to produce images of the sky. Stellarium[4] is a popular open source alternative to Starry Night.

2. HISTORICAL BACKGROUND

To answer our original star/planet question, you must have at least two images of the night sky at different times. You may wish to intentionally include a planet, asteroid or some other suitable object for your students to discover. Before the era of computers, astronomers might spend days studying photographic plates and looking for changes. In 1930 Clyde Tombaugh discovered Pluto by comparing photographic images taken on January 23rd. and January 29th.. These original images are shown in Fig. 1 and illustrate the concept behind this laboratory exercise. In those days images were compared by eye using a blink comparator. An astronomer using the comparator could view one plate and then another, with the images switching back and forth several times in a second. Any difference in the two photographs would show up as a blinking dot. Now, with commonly available image processing software, the task is simplified. One image can be subtracted from the other to produce a difference image. As an example, we can produce a difference image from the two photographs shown in Fig. 1. Photoshop® contains a "difference filter" that can perform this operation. Each of the original images is saved as a layer and the difference filter it then applied. I often set the opacity of the upper layer to about 50% so that I can see through the layer and properly align it. Using this technique, we can immediately see what moved as shown in Fig. 2. The dark spots represent stars that have not changed their position. They are black which corresponds

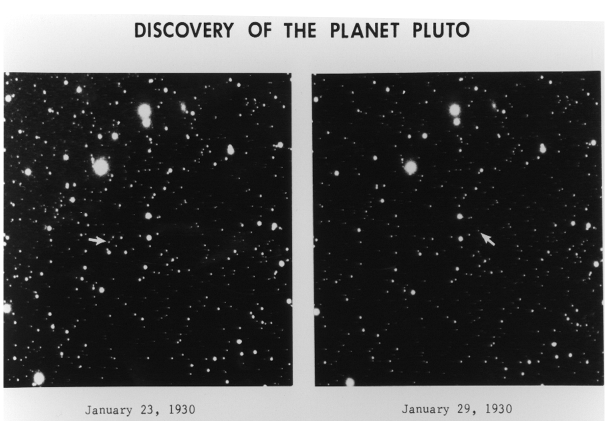

FIG. 1. Photographs examined by Tombaugh. The arrows indicate the wandering object. Image from Lowell observatory archive, used by permission.

to the smallest difference between the images. The white and gray dots near the arrows correspond to Pluto's position on the two different nights. What we have just accomplished is to "rediscover" Pluto from subtle differences between the original photographs. The entire point of this paper is to show how our students can make their own discoveries. Introductory astronomy students can employ the same technique and discover objects in actual photographs, or in images created by planetarium software. One should note that a few smaller differences are also visible in Fig. 2. This is not surprising, since the stars in the January 23rd. photograph seem to be brighter than those in the January 29th. photograph. Subtle difference may just be the absence of fainter stars.

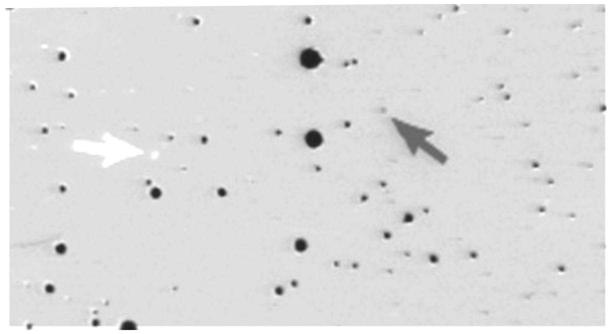

FIG. 2. The difference between the two photographs shown in Fig. 1. A selected area has been enlarged to clearly show Pluto on two different dates.

3. PRODUCING DIFFERENCE IMAGES

Planetarium software allows us to generate images for our students to analyze. We should use two images that represent sufficiently different times, so that changes in the object's position are discernable. Here is an opportunity to help students understand the concept of sidereal time. When looking for changes in the position of the object we need a reference point. Images that have an arbitrary time interval between them need to be rotated and shifted in order to match up, while those taken one sidereal day apart are easier to align. This is an instructive point and can be included as part of the laboratory exercise. Fig. 3 shows two images of the sky exported from Starry Night®. The observing position is Atlanta, GA and the field of view is 60°. The objective is to see if we can spot any differences between the two figures. An old time astronomer would have to carefully examine photographic plates. We have the advantage of using any image processing software that can subtract two images. To simplify the analysis, these images were made three sidereal days apart. Since the time interval is three sidereal days, the star field should not have changed. That means planets or asteroids should have moved relative to the star field. Notice the sky is white in these illustrations. This gives the feel of a

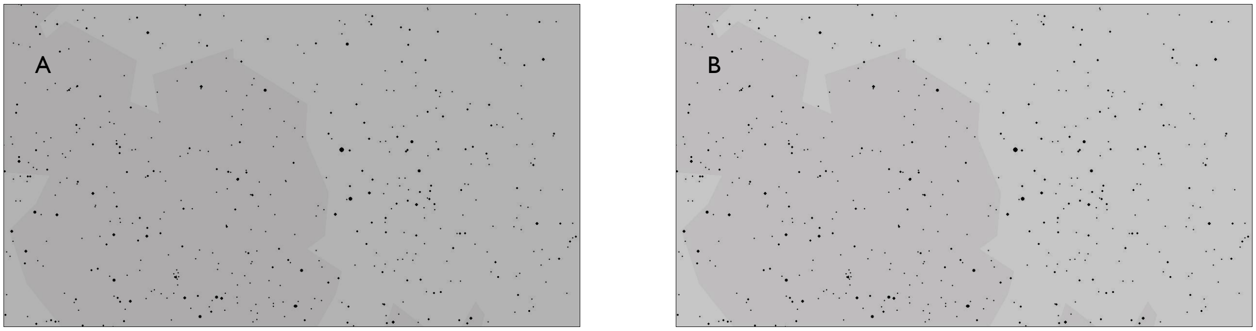

FIG. 3. Two views of the sky from the same location, with frame B three sidereal days after frame A. A sharp observer can see that two objects have moved relative to the star field, the difference image simplifies the task.

when printing laboratory handouts. You might guess that the bright object (heavy black dot) is a planet, but can you find the asteroid?

Armed with these images, students can now begin the process of discovery. By employing image processing software, such as Photoshop®, we can find the difference between these two images and see what has changed. In the case of Photoshop® we can set each frame to be a layer. Frame B is then placed over frame A. This automatically makes frame B the second layer in the image. The opacity of frame B is set to about 50% and the image is simply dragged around over the "background" layer (frame A). At this point the "difference" filter is used to subtract the images. As one arranges image B over the background, it becomes obvious which objects have moved in the sky. If you wish you students to identify the objects then they need a little bit more information. Depending on the learning objectives, you might wish to use an image with right ascension and declination grids superimposed. For the objects shown in Fig. 4, object 1 is Jupiter and object 2 is Vesta. Fig. 5 shows what happens if you simply overlay two images that differ by 3 solar days. Since the time difference is 3 solar days the star fields will look slightly different. In this case, it is much more difficult to line up the images. This difficulty in alignment can be used to emphasize the difference between solar and sidereal time.

4. SUMMARY

We have used this technique with great success in our introductory Astronomy class. Students enjoy "discovering" objects and they gain a greater appreciation for the discoveries made with only photographic plates. This exercise can also be used to introduce the idea of automated surveys searching for potentially hazardous near Earth objects (NEO's).

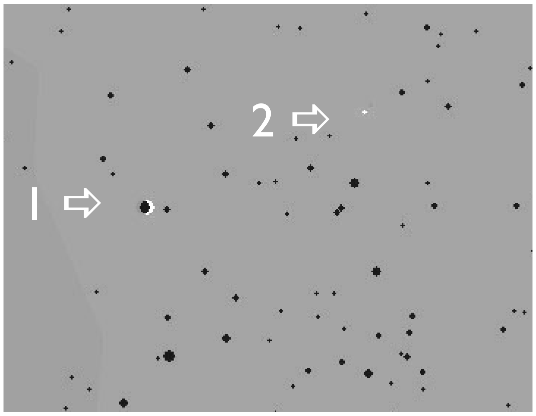

FIG. 4. The difference between the two frames in Fig. 3. This reveals the moving objects. Black indicates perfect alignment and white indicates a large difference. A selected area has been enlarged to clearly show the objects.

FIG. 5. These images are taken three solar days apart and are not as easy to line up.

ACKNOWLEDGEMENTS

I would like to thank the students of my spring 2007 Astronomy class for their assistance in developing this laboratory exercise. Special thanks to the Lowell Observatory library of the use of the Pluto picture.

[1]Starry Night® is a registered trademark of Imaginova Canada Ltd.

[2]Photoshop® is a registered trademark of Adobe Systems Inc.

[3]http://www.phy.duke.edu/~kolenaimagepro.html, image processing resources for Astronomy teaching.

[4]http://www.stellarium.org/, open source planetarium software.

Early results in a study of written versus online homework

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Presented here are preliminary results of an investigation comparing exam results for students completing online homework as opposed to written homework. The goal of the project is to determine which homework mode is more beneficial to students. The overall design of the experiment and some early findings will be discussed. At the time of presentation, subjects enrolled in this study completed approximately two-thirds of the study.

1. INTRODUCTION

As the world becomes more technologically dependent, both society and academia continue to press for more and more incorporation of computers and related technology into curricula. The trend among math related courses seems to be to require students to perform homework online instead of submitting written homework to be graded by the instructor or other personnel. Naturally, this begs the question of whether online homework is a better learning tool or even an equivalent learning tool for students. While online homework, which requires no personal grading, is certainly more convenient for instructors, does this trend benefit students or does this trend do them a disservice?

Both homework styles have advantages and disadvantages. Online homework, besides being convenient for the instructor, provides instant feedback for users and allows for students to attempt the problem repeatedly. Online has disadvantages of having an all right or all wrong approach and often will only give general feedback on how to solve the problem. Written homework, however, has the advantage of allowing for partial credit from the grader and granting the opportunity for the grader to provide specific, individualized feedback on a student's solution. The disadvantages for written homework include a delay in feedback of a few days, and only permitting one attempt for each problem.

2 EXPERIMENT

In this experiment, students enrolled in two separate sections, with two separate instructors, of introductory algebra based mechanics, were divided into two groups. The students were assigned to the groups using their academic background information of current institutional GPA, transfer status (backgrounds with little GPA information), and if the student had attempted the course before. These parameters were used to ensure that one group was not inherently stronger than the other. Students that did not perform a majority of the homework were removed from the study, which left 15 students in Group 1 and 17 students in Group 2. The courses were designed with three hour exams and a final exam. Group 1 was required to perform written homework for the material covered on the first exam, perform online homework for exam two material, and perform written homework for the third exam material. Group 2 was required to perform the exact same homework problems in the opposing style from Group 1 during the same time periods. All written homework was graded by only one instructor throughout the semester. Online homework was setup using the Mastering Physics homework module from Pearson Education. Students' hour exam scores were used to determine overall performance during each portion of the experiment.

3. RESULTS

Overall, students in both groups, on average, performed better on the second exam than they did on the first exam. Improvement for all students can be attributed to a variety of factors including the possibility of relatively easier material on the subsequent exam and student acclimation to the course. Interestingly, however, Group 1 (switched from written to online) had an average improvement of just over eleven points while Group 2 only managed an average improvement of 2.4 points.

Given the nature of the data coming from different students, with different instructors, and taking different hour exams, Z-scores were also computed to normalize the data for each hour exam. On Exam I, Group 1 (written) had an average Z-score of -0.051 and Group 2 (online) had an average Z-score of +0.045, suggesting that Group 2 slightly outperformed Group 1 on the first exam. On Exam II, Group 1 (online) had an average Z-score of +0.263, while Group 2 (written) had an average Z-score of -0.232. Here, Group 1 far exceeded Group 2. In both cases, students using online homework outperformed students doing written homework. The second exam shows a dramatic shift in scores from the first exam in favor of online homework. It should be noted that at the time of presentation, only the homeworks and corresponding exams for the first two phases had been completed. A full analysis of all data needs to be performed once the experiment is completed.

4. SUMMARY

These preliminary data show that students performing online homework, on average, have a higher achievement on exams than those that perform written homework. This suggests that the shift in homework mode from written to online does, indeed, benefit students and that online homework is actually a better learning tool than written homework.

ACKNOWLEDGEMENTS

I would like to thank the students that participated in this research. I would also like to thank Gerd Kortemeyer for his advice and help. Special thanks to Pearson Education for granting Mastering Physics licenses to the students.

Conceptual physics: studying and teaching introductory mechanics

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Teaching Mechanics in the introductory Physics courses provides the teacher with a great opportunity to expose students to the powerful ideas of modeling in Physics. The seeming simplicity of the subject of the study sometimes appears as a complication because of misconception. When the common sense assumptions are not emphasized sufficiently to students, they might not even occur to them or they don't leave a significant trace in their minds. Students worship learning through their own hands-on experience and love to create their own rules of thumb. It is very easy to take for granted what one can see with her/his eyes and to create a misconception based on the apparent clarity of behavior of objects on the scale of our everyday experience. Things are often not what they seem to be. Students might not necessarily understand some ideas that are obvious for the teacher.
This paper is about the importance of exposing the concepts hidden behind the routine procedures and so correcting misconceptions and clarifying the assumptions in the modeling processes in Mechanics.

1. INTRODUCTION

Discussion of the etymology, history and meaning of the term "Conceptual Physics" could become a theme for an entire conference of experts in Physics together with experts on Cognition.

Without pretending to provide a perfectly unified definition, but based on my understanding of numerous descriptions of how experts from a variety of disciplines see it, let us accept the following: Conceptual Physics is the system of patterns or connections between situations that are not obviously related. Conceptual Physics identifies the key or underlying issues in complex situations. It includes using creative, conceptual or inductive reasoning.

Unfortunately, a misconception on the very term Conceptual Physics occurs even among the teachers of Physics.

How could Physics not be conceptual?

According to Paul Hewitt, Conceptual Physics and mathematical description in Physics are not opposing ideas. He does not deny the power of in favor of "conceptual" word description; on the contrary, he gives a lot of credit to the discussion of equations instead of just substituting numbers and calculating the results.

He is a great fan of mathematics as the tool capable of identifying patterns or connections between situations that are not obviously related. This matches exactly the definition of the term "Conceptual"[1,2].

After clearing this basic misunderstanding, let us consider one of the frequent causes of misconceptions. In the attempt to understand and explain the essence of a process or an event, one would think first to identify the pattern, the concept of the subject.

After shouting "Eureka" at the peak of excitement of discovery, a hypothesis would be formulated and studied to either prove or disprove it. Then hands-on-experience comes that brings actual comprehension. The next step in the process of cognition often consists of simplification of the procedure leading to the routine procedure. Here is a great source of misconception. Most of the routine procedures are designed based on specific conditions of a particular case. An inexperienced student, whose knowledge is based on a given routine procedure rather than the sequence of conclusions coming from the conceptual understanding of the route, of this procedure, may draw conclusions leading to misconception. Probably every teacher has had a student sitting always in the first row working hard to comprehend the material, processing the ideas through her/his brain and always trying to make her/his own shortcut rules. This shows good intentions, but only sometimes were those rules reasonable; unfortunately, most of the time the "homemade rules of thumb" lead to misconception. It happens sometimes that some teachers or tutors lead students' to misconception by providing them with the rules of thumb that always have "oversimplification" of the model of the process. The disadvantage is in the fact that sometimes students forget about the conditions of the rule and expand it to a wider class of events. Here are some examples.

2. THE MYTH ABOUT ALWAYS NEGATIVE "g"

One of the most common misconceptions is the statement that "acceleration due to gravity g is always negative". First of all, g represents the absolute value of the **g** of the acceleration due to gravity, so it is a positive number by the definition of what absolute value is. Why do students forget this fundamental idea from vector algebra? Don't we have it written in one of the first chapters of each Physics textbook?

It was probably a simplified "rule of thumb" designed by a student to simplify memorizing the routine procedure of solving some problems on projectile motion. It could be even supported by some teacher, who simplified the model down to some problems planned for this particular student, or class.

The strong belief is often based on the success in physical science class in elementary school and the authority of a beloved teacher. To help students to overcome such a prejudice, they should be exposed to the complete description of the model of the process and the difference should be emphasized.

Example 1. Toss a ball.

To determine the initial velocity of the ball tossed straight vertically upward you recorded time t how long the ball was in the air since it left your hand at the height h till it landed on the floor.

The assumptions are that the air resistance is negligible, and the acceleration due to gravity is directed vertically down, in the range of displacements considered in the problem it can be assumed as constant and in your place its magnitude is 9.81 m/s^2.

The one dimensional motion with the constant acceleration can be described by the following equations:

$$\begin{cases} \vec{v}(t) = \vec{v}_0 + \vec{a}t \\ \vec{x}(t) = \vec{x}_0 + \vec{v}_0 t + \dfrac{\vec{a} \cdot t^2}{2} \end{cases} \qquad (1)$$

It is essential that these equations establish relationship between velocity, position and time for each instant of the motion and each point on the trajectory. It is reasonable to choose vertically upward direction as the positive direction of the x axis, as there is motion in both directions. In this case vector **a** represents acceleration due to gravity **g** and it is pointed in the negative direction, **a** = -**g.**

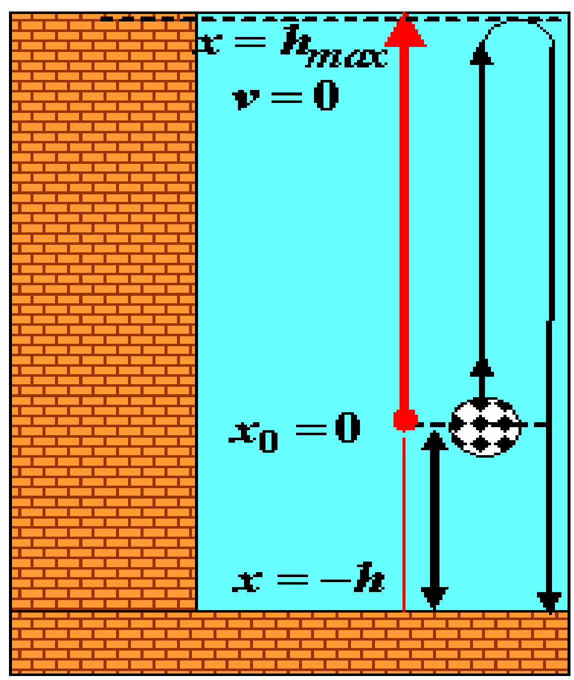

FIG. 1. Positive direction points vertically up.

Nevertheless, it has magnitude of |a| = g >0. Placing the origin of the reference frame at the point where the motion starts, for the initial conditions we have:

$$\begin{cases} v(0) = v_0 > 0 \\ \vec{x}(0) = \vec{x}_0 = 0 \end{cases} \qquad (2)$$

Now the general set of equations (1) should look this way:

$$\begin{cases} v(t) = v_0 - gt \\ x(t) = v_0 t - \dfrac{g \cdot t^2}{2} \end{cases} \qquad (3)$$

It is essential to mention that the minus sign in front of g represents the fact that vector **g** has direction opposite to the positive direction of *x*.

It is clear from these equations that after some instant *t* where

$$t > \frac{v_0}{g}$$

velocity becomes $v(t) < 0$, also after some instant of time the position becomes negative: $x = x(t) < 0$.

The initial velocity can be easily found now from the second equation in (3) using the recorded time $t = t_{TOT}$ and the depth of the floor with the respect to the starting point $x = -h$.

Example 2. The Height of the Staircase

To determine the height of the staircase, you drop a tennis ball and record the time it takes the ball to reach the floor. The assumptions are that the air resistance is negligible, the acceleration due to gravity is directed vertically down, and in the range of displacements considered in the problem it can be assumed as constant and in your place its magnitude is 9.81 m/s^2.

Once again, we would start with the same equations (1). As the ball was released from rest, the initial velocity was zero. We can place the origin of the frame of reference at the point where the motion starts and as the only direction we have in this situation is motion vertically down, we will assume it as the positive direction of the frame of reference, see Fig. 2. Vector **a** is directed vertically down and it has magnitude |a| = *g* >0. Now the general set of

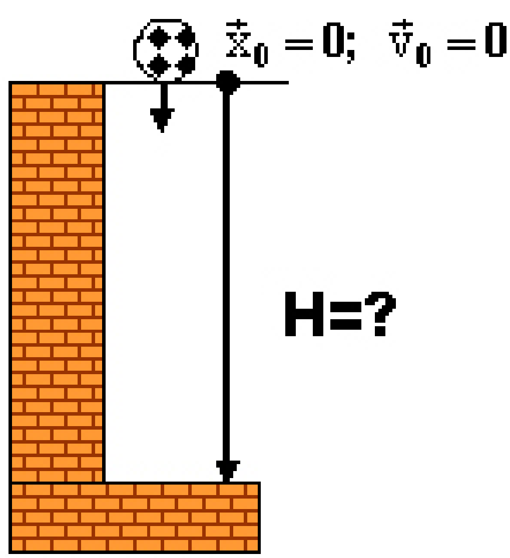

FIG. 2. Positive direction points vertically down.

equations (1) should be converted into the following:

$$\begin{cases} v(t) = gt \\ x(t) = \dfrac{g \cdot t^2}{2} \end{cases} \qquad (3')$$

In this case there is no negative g, neither there is a minus sign before g in the equation.

Everything is positive in this kind of a problem with the motion in the direction downward if this direction is chosen as the positive direction. I believe that your students would shout here: “Gee….! Positive “g”!”.

I agree, let us be positive! Why in the world the downward direction would be chosen as the negative in this case? To answer the question of the problem about the height of the staircase one should use the second equation from (3):

$$h = x(t_{Tot}) = \frac{g \cdot t_{Tot}^2}{2} > 0$$

Example 3. The Simple Pendulum

The period of a simple pendulum

$$T = 2\pi\sqrt{\frac{L}{g}}$$

and its natural frequency

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

are exposed to students much further in the course of Physics. There is no doubt that here g is positive too: “Gee….! Positive “g”!”.

Another frequently appearing misconception is based on the consumer perception of mathematics. This is, instead of seeing equations (1) as a story of the motion where the relationship is established among the velocity, position and time for each instant of the motion and each point on the trajectory, many students see them as “formulas for calculating specific values.” The first equation in (1) is often considered as “formula for the final velocity” and the second is considered as “landing distance”, which they are only for a specific value of $t=t_{TOT}$, total time in the air.

Example 4. The Range of the Projectile

This example gives a great opportunity to explain the concept of the motion with the constant acceleration/ deceleration. Nevertheless, there is some room for confusion for the students.

$$\vec{x}(t) - \vec{x}_0 = \frac{v_0^2 \cdot \sin 2\alpha}{g} \qquad (4)$$

While some authors[4] define the term “range of the projectile” as the horizontal displacement between launch and landing, others[5,6] narrow it down to the case of motion between two points of the same height. Even though it is perfectly correct and even useful for comprehending the concept of motion with the constant acceleration/deceleration, it creates misunderstanding by making an impression that it is a "formula of the range of the projectile". Many students miss the fact that "formula" is correct only for that case when the landing is at the same height as the launch point and use formula (4) to determine any horizontal distance traveled by the projectile.

3. CONCLUSION

The role of the textbook author is of great importance in the teaching process, but sometimes the role of the teacher is even more important. As much as contemporary technology can make the textbook interactive, it is still just a book and just technology. The teacher is not just a "middle man" who connects the student – the customer – with the "manufacturer" – the Physicist who discovered the laws of Physics.

The teacher is an alive and thinking individual, who makes the "books" speak. To help my students hear, remember and record my vocal comments as the teacher, I created a series of workbooks for making lecture notes written in the genre of mathematical prose[7-10]. This way mathematics helps to underline the concepts and relate them to each other. The students record the teacher's comments in the workbook after processing them through their brains.

Physics is a tool to understand the world around us and to solve related practical problems; nevertheless, in teaching

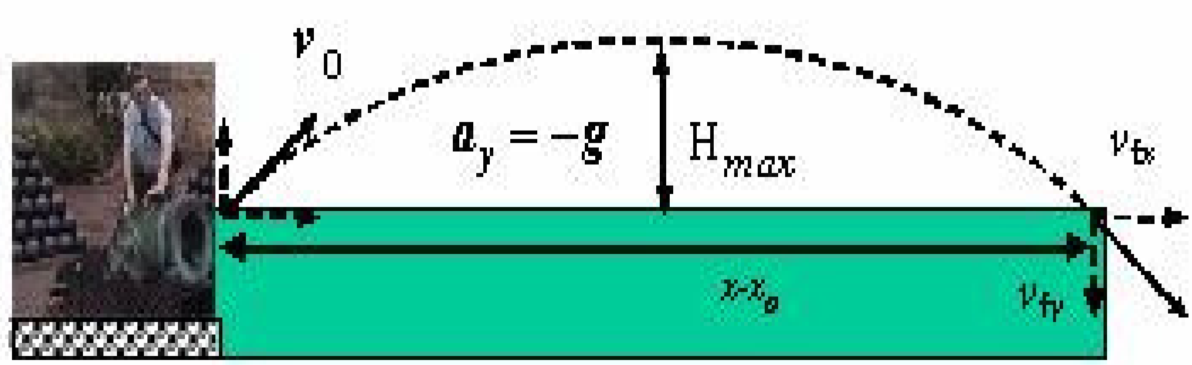

FIG. 3. Exclusive case of landing at the height of the launch.

we should distinguish education from training. Understanding the concepts would eventually create the ability to solve particular problems. However, ability in solving particular problems might never lead to understanding the concept that is lying behind it.

Understanding "where the formulas come from" prevents misconception in their use. The conceptual understanding could be more easily achieved by employing the mathematical prose as the genre and mathematical modeling as the language. Avoiding mathematics doesn't make Conceptual Physics. Employing mathematical prose gives the ability to distinguish differences in similar and to recognize similarities in differences composing one of the deep meanings and purposes of education as opposed to training, as just ability to perform sequence of operations.

[1]Paul Hewitt. Conceptual Physics. 7th ed. 1992

[2]Paul Hewitt. Developing Conceptual Physics. 2008 AAPT Winter Meeting in Baltimore. Plenary Presentation, Onsite Guide, p. 49

[3]J.D. Wilson and A. J. Buffa. College Physics. 4th.ed. p. 86. Prentice Hall ISBN 0-13-082444-5

[4]Eugene Hecht. Physics : Algebra/Trig; p. 73, Thomson Brooks/Cole; 2nd edition pp. .1146+ (1998) ISBN 0-534-26100-0

[5]J.D. Cutnell, K.W. Johnson. Physics.6th ed. p. 64. John Wiley & Sons, Inc. pp.992+. ISBN 0471-15183-1. 2004.

[6]J.D. Wilson and A. J. Buffa. College Physics. 4th.ed. p. 86. Prentice Hall ISBN 0-13-082444-5

[7]Mikhail M. Agrest. Lectures on Introductory Physics I. Revised 249 pp. with illustrations, Thomson Learning. ISBN 1426625596, 2007.

[8]Mikhail M. Agrest. Lectures on Introductory Physics II. Revised (Algebra Based Course).252 pp. with illustrations. Thomson Learning., 2006. ISBN 0-759-39304-4.

[9]Mikhail M. Agrest. Lectures on General Physics I. (Calculus Based Course). 257 pp. with illustrations. Brooks/Cole, Thomson Learning. ISBN 0-759-35047-7, 2005.

[10]Mikhail M. Agrest. Lectures on General Physics II. (Calculus Based Course). 237 pp. with illustrations. Brooks/Cole, Thomson Learning. ISBN 0-759-36060-X, 2005.

Tee Zero: A game of symbolic manipulation.

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We present Tee Zero – a physics based game currently being developed by Big Fun Development company. The purpose of the game is to improve a student's fundamental ability to work with symbols while interacting directly with scientific phenomena. Tee Zero will offer a unique opportunity for many students who are learning poorly from books, lectures and even computer-based training: they can explore mathematics and exercise their skills on their favorite learning device: the videogame console. Tee Zero offers parents and teachers a cost effective alternative to tutors, remedial classes and out-of-school test prep programs. The game is expected also to be attractive to the advanced middle school students, particularly in rural and urban schools, there may be no advanced math track.

1. INTRODUCTION

Being science educators we often complain about the poor mathematical skills that students bring into our classrooms. The new national standards are introduced, the mathematical curricula are restructured, but that seems to have very little impact on the final outcome: all of us can provide plenty of anecdotal evidence that American high schools do not prepare enough graduates with strong math and science background. Many factors responsible for the lack of proper preparation are well known, among them the insufficient supply of qualified teachers, but also general anxiety or, at best, apathy toward mathematics and sciences. The situation is so critical that even math educators start to argue that we should simply stop teaching math skills to the majority of the student population altogether, educating in math only the chosen few who show aptitude and interest early on[1]. Although not without merit, this policy, if implemented, could only lead to further deterioration of basic math skills and understanding of basic concepts. Nevertheless it is quite well known that this insufficiency of basic math skills seriously hinders the progress toward the career goals among the general student population, but especially among women and minorities[2], sometimes essentially blocking for them any career paths that require a minimal proficiency in math and sciences. One can argue that surely the situation cannot be that bleak, with so much effort spent lately on the improvement of STEM education, but the statistics that follows suggests the opposite. An informal survey of incoming pre-engineering students at Claytion State University presented in Table I shows that 13 % of our students required remedial math upon enrolling in the program, while additional 47% required a College Algebra course. Needless to say that neither course is an optimum starting point of an engineering curriculum. More, success rates at two Clayton State mathematics courses: College Algebra and Pre-Calculus for years 2004-2007 fluctuate around 60% meaning that 40% of our students cannot overcome the hurdle of math on their path to potential careers.

For a student, a failure to succeed in math courses not only delays the start of a science sequences, but usually continues to haunt the student throughout his entire college stay. It can be argued that most of the failures we see in introductory physics and chemistry courses are due to poor math, especially algebra, skills. But for a science educator even more important than the ability to crunch the numbers is the fundamental ability to work with symbols. One of the greatest challenges that our students face in physics courses is how to learn to represent scientific principles in symbolic mathematical terms. In fact, anyone who teaches physics knows that the hardest part of solving a problem is usually the translation of information given to a student into a set of physical variables. Most of the students learn the skill eventually but much frustration results in the meantime.

Course	MATH 0099 Remedial Math	MATH 11111 College Algebra	MATH 1113 Pre-Calculus	MATH 1501 Calculus I
Number of Students	5	18	10	5
Percent	13.16	47.37	26.32	13.16

Table. I. Survey of the mathematical placement of incoming pre-engineering majors at Clayton State University.

2. THE SOLUTION: A GAME OF SYMBOLIC MANIPULATION

One of the strategies that became popular lately is to increase a student's interest by teaching math through its application to the science and technology projects. Another one is to take advantage of the natural affinity of modern students to technology.

We propose to utilize the latter by developing Tee Zero project – a game to improve a student's fundamental ability to work with symbols by allowing students to master meaningful symbolic manipulation in the non-threatening, stimulating environment. Tee Zero presents Introductory Physics I topics (projectile motion, dynamics, energy transfer), but the main focus is on learning to use the symbolic notation and mathematical operations. With the right presentation, algebra is a game (or at least a puzzle). In the right game environment, players will develop skills at problem solving that will transfer directly to performance on standardized tests, and ultimately in science classes.

A. Mathematics of the game

Any player can, at critical points in the game, choose to use mathematics instead of intuition to play the game. The game tools present algebraic operations as pleasurable puzzle solving. Despite the full-featured sport engine, the game is designed to focus the players' time, effort and satisfaction on the solution of geometric and physical problems using the manipulation of symbols.

B. Sport: mini golf

Tee Zero is a miniature golf course, where each hole is associated with a physics formula and a math skill. Each hole can be won by solving the equation or a player can skip the math and just guess. Golf is won by correct shots, so players who skip the math and guess will be at a big disadvantage. One of the advantages of the mini-golf is that time exerts no pressure in it, there is no penalty for stopping to calculate. As a result, players can easily cross the bridge between game playing and math. A great variety of formulas can be presented as plausible miniature golf holes. More, individual holes associated with particular formulas can be assembled and reassembled in courses.

C. Math skills

An analysis of the Math SAT has yielded a set of critical algebra skills among which are coordinate geometry, substitution and simplification , exponents, solution of linear, quadratic, and simultaneous equations, etc. All of these skills are naturally required for analyzing motion and can be very easily associated with a particular minute golf hole. Math topics can be assembled into a sequence of mini golf holes based on the increasing complexity of mathematical skills required for their solving with each hole adding slightly more difficult math operations to the hole before it.

3. SUMMARY

Presented above is the concept of Tee Zero: a game to improve a student's fundamental ability to work with symbols while interacting directly with scientific phenomena. The game will offer a unique opportunity for many students who are learning poorly from books, lectures and even computer-based training: they can explore mathematics and exercise their skills on their favorite learning device, the videogame console. It is hoped that Tee Zero will offer parents and teachers a cost effective alternative to tutors, remedial classes, and out-of-school test prep programs. Although proposed primarily for high school students, we also expect the game to be attractive to the advanced middle school students, particularly in rural and urban schools, there may be no advanced math track.

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[1]K. Devlin. Why we should reduce skills teaching in the math class. http://www.maa.org/features/skills.html

[2]P. Mlsna et al. Mathematics skills assessment and training in freshman engineering courses.http://mae.nmsu.edu~aseemath/1697_MATHEMATICS_SKILLS_ASSESSMENT_AND_TRAINI.pdf