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USE OF THE INTERNET IN TEACHING PHYSICS

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USE OF THE INTERNET IN TEACHING PHYSICS

ABSTRACT

By

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Another source of information for high school physics students is needed. Course materials were developed for students to use over the internet, which included notes, derivations, images, movies, simulations, and problems to solve. A sample of students would use the online coursework for one entire unit, without any interaction with the teacher. Upon completion of the unit, these students took the same test as students who remained in class and received more traditional instruction, including notes, demonstrations, tactile lab activities, modeling problem solving, and problem sets.

This process was performed twice. In both trials, the test results were not significantly different from each other.

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Use of the Internet In Teaching Physics

Students miss my senior level physics classes frequently, for a variety of reasons, including field trips, illness, and student government responsibilities. When they return from an absence, there are problems for them and for their teacher. They may have missed material that is particularly difficult. They may or may not ask for the work missed. Perhaps a laboratory activity took place, which is difficult to make up. Students may also copy the lecture notes their peers took, which may not be reliable. Students making up work may feel rushed or that they are missing out on the depth of material received by their classmates. Students who miss class must rely more on their textbook than those having had the benefit of experiencing a discussion or seeing a demonstration. Telling a physics student to go home and study the first two sections of the vectors chapter might be to set them up for failure. In any case, both the teacher and the student have to deal with the problems and logistics of make-up work.

Any way to provide students with more exposure to course topics would be helpful for students even if they had not missed class. The internet could provide such a way to help students learn course content. It provides a means of getting information to the student quickly, and it is already being used to give students a "Global Lab" where they can connect with people and information all over the world. (Schrum and Berenfeld, 1997) Students can also be assessed via the internet. Students could decide when to work, how much time to spend on work, and if they were ready for some type of assessment. My school currently uses computer-based lessons in several classes, and lessons requiring use of the internet are common. Many schools across the nation, including mine, are beginning to provide a "virtual high school" over the internet. The State of Michigan is supporting public school use of a program called *blackboard.com* to allow public schools to host online classes for any high school student to take for credit. While still in early stages of development, this avenue is being explored by many public schools.

Since the internet is "easily updated and can be interactive", it can be an ideal supplement to using a textbook for making up work. (Roblyer, 1997) The internet could provide a way to help students with a variety of problems, as mentioned previously. If there were one more particularly attractive way to present materials, students who access them could have an advantage. (Brooks, 1997) Sometimes, students who attend class need extra help. Even in a comfortable environment, some students may feel shy about asking questions. If students working on their own can't come up with a suitable plan of attack for their problems, homework assignments can be impossible to complete. Studying for tests would also be easier if there were some way for students to gauge their own preparedness. Likewise, some students may feel the need for, or have more interest in information about a certain topic. They may be interested in a career related to a topic, and want to see what they may have to deal with in that line of work. Offering materials online also could provide the means to meet the needs of students who are ahead of the rest of the class, or behind.

The internet may also provide a fresh medium for students with differing learning styles. Regardless of their individual learning patterns, the internet has been shown to be able to provide materials in a way that benefits students. (Distance Learning '98) Some students are auditory learners while others require tactile experiences. Others may learn best from reading text and viewing pictures. If a particular lecture confuses a student, they may find their textbook helpful. When the internet is introduced into the curriculum, using a mix of the traditional textbook and web-based assignments can be beneficial. (Roblyer, 1997) All students can reach the same level of achievement with web-based materials, regardless of their particular learning style. (Distance Learning '98)

Sometimes, there are demonstrations and lab activities that a teacher cannot fit into a designated time frame, or they did not blend well with the rest of the unit. Some may find it useful to see these demonstrations in a book or on videotape. Providing an additional medium such as web-based materials for curriculum presentation can only be beneficial if students take advantage of it.

In my teaching experience, I have seen what I would call a predisposition toward thinking that any new method of teaching has some advantage, and that all good teachers should adopt it. Claims are made that "Through internet-based courses, Virtual High School significantly enhances each school's curricular offerings and integrates the best technologies." (Berman and Tinker, 1997) However, a study done at the college level showed that when a new student-driven, computer-based introductory physics course was first offered, its students had a final grade only slightly higher than their traditional lecture based peers. These students met at the same time as those in lecture hall situations, but used computer based lessons to do their course work. Some students from both the traditional and the computer-based sections went on to take another physics course later. The grade difference disappeared. (Mottmann, John, 1999) In fact, numerous studies have reported that there is often "no significant different difference" between the results of students in traditional classrooms and those learning at a distance. (Russell, Thomas, 1999)

The project described in this paper was undertaken to determine whether students working on web based instructional materials had any advantage over traditional in-class learners. If working with web-based materials could provide students with an equal footing to their in class peers, then the online format would deserve more attention.

Many students in the school where this study took place, Beaverton Rural Schools, come from low socioeconomic levels. There is a very small percentage of minorities, the most prevalent being a small Hispanic population. At least sixty percent of the students qualify for free or reduced lunch. The local area has a high density of production factories, and these places employ many of our school's recent graduates and their close family members. Students in my physics class tend to be among the most highly-achieving in our school. About three-quarters of these students go on to attend college the year after graduation from high school.

Research Process

During July of 1998, I took a course on campus at Michigan State University, designed to help teachers put pages on the internet. I produced my first web page in this class, and have continued publishing pages since. I took an online physics course myself the following fall semester through MSU. I had a very worthwhile experience and decided that I should make this resource available to my students if possible. The next summer, I had the opportunity to work on a research topic. I spent about four weeks writing resources for my students to use online. Time was also spent searching the internet for already existing resources. The author of the software I would be using later showed me how to use it, and since then, I have produced and organized resources for several physics topics, but chose only two of these for this study. The program is essentially an organizational tool resembling a common internet browser. It is called "Lecture *OnLine*", and is currently used by several courses in diverse areas of study. Online instructions are available for those developing a site with the software. (Brecht and Kortemeyer, 1999)

<u>Structure Of The Online Units</u>

All students have access the school's internet linked computers to work on course materials. To keep their interest while providing a meaningful learning experience, the online tasks should be varied.(Roerden, 1997) In my online course, students were engaged in performing three types of tasks; reading web pages, solving problems, and using online application software. Specifically, students had access to the following resources online:

(see appendices B-I through B-VI for examples):

- Chapter goals for understanding
- Notes
- Equations/derivations
- Sample problems
- Links to visit outside sites
- Simulated hands on activities
- Movies
- Audio

Consistent organization of the web pages was important so that the students would have a familiar framework to use. If the format of the materials changed from topic to topic, students may have wondered if they were doing what they were supposed to be doing. For this reason, each page was broken into similar sections with a different heading to tell the students what was in that section.

Each online chapter begins with a page outlining the goals for that chapter so that the students would have a sense of why they were doing the work. Students also knew that their tests were written based on these goals. The teacher can use the software online to see which problems the students have solved and can read/reply to emails, but the students themselves must decide on their own if they have mastery in any topic. (Porter, 1997)

The chapter web pages were designed and written to correspond to and take the place of lecture materials provided traditionally to in-class students. Each page contained one topic. For example, one page may contain the instructions on how to find the slope of a line. I felt that breaking content into smaller "bites" would make the pages more approachable. I worried that if the pages required students to scroll up and down too much, they could become bored or overloaded and not see all the content.

Each individual topic was described and sample problems were given on the pages. Mathematical derivations were provided in places where I felt they were of particular use, or showed a special relationship between the facts and the final equation. Pictures or graphics were included as often as possible, as well as sample problems with their solutions. Several pages contained movie clips that could be downloaded and analyzed.

A similar approach that achieved positive results was used in a physics class at Dickinson College, Pennsylvania. Students used image software to study the motions of objects in movie files and used physics to see if the motions were realistic. (Laws and Pfister, 1998) With this format, teacher involvement was direct, but students spent much of their time interacting with each other and the technology.

Equations were also given on the web pages. Sometimes important equations arose directly from the written text, and sometimes I showed their derivation in a series of steps. In either case, in writing the pages, I tried to show all of the logic and steps necessary to arrive at a useful equation.

Links provided students with sites to visit for more information, or for some type of activity. Some of these sites contained interactive programs, or "applets" written in Java and run directly in web browsers. (Hwang, Fu-Kwun,2000) Over ninety percent of all internet browsers do support Java, and all of our school's computers are Java-ready, so this was not a problem for my students. All sites were inspected to be certain that there were was no inappropriate material presented. No student or instructor knowledge of programming is required, and the sites provided students with simulations of real world situations. For example, one applet let students alter the launch angle of a cannon ball to see the effect of changing trajectory on range. Students could also change the mass of the ball and see that this had no effect on the range. Sites like these are a valuable supplement to my web page notes and problems because students working online could not see any of the demonstrations or participate in laboratory activities in my room. (see Implementation for further information) By providing students with a hard copy structured question sheet, I could guide them through the use of various applets, and lead them toward understanding the goals for that chapter.

A chat room was provided as part of the web site where students could communicate instantly with other students who were also currently using the pages. Messages or questions could be left for others to see. This provided an ideal environment for cheating, but the students were already working unsupervised in the school media center.(see Implementation for further information) To find out how to solve an online problem, a student could easily find and ask another student who had already completed the problem. An antidote for this problem is built in to the software. Each student's problem was worded similarly, but used different variables. Students could not entirely escape working out the problem unless they had friends willing to do the work for them.

The chat room is intended as a place where students could "share and discuss data and ideas, and collaborate on problem solving." (Roberts, Blakeslee, Brown, Lenk, 1990)

The Online Problems

The software used to sequence the web pages and write the problems was written by Dr. Gerd Kortemeyer, a specialist at Michigan State University,. His presentation is based on creating a separate web browser that operates within whatever browser a student is using. The instructor writes web pages and uses special tools to sequence them for presentation. The software is titled "Lecture *OnLine*". Students call up the proper internet address and log in. From that point, everything students see is part of the teacher's lesson plans. Before students can enter the site, the instructor must enter some data so that each student can receive a secret password and a public login name.

Michigan State University offers several courses using this software. Dr. Kortemeyer allowed me to set up my own class using Lecture OnLine. Upon entering the site, students initially see a selectable list of chapters for the class. Once they select a chapter, they then see a list of the pages in that chapter. They can select any page to view within that chapter. Chapters can contain the elements described earlier.

The online problems could be presented in different formats, listed below. Keeping the question formats varied helps prevent students from falling into a routine of repetitive assessments, and helps students who may have a predisposition against one particular question type.

To use *email feedback* questions, the teacher writes a typical question and the student formulates their response and clicks a button to send it to the teacher. One such feedback question asks students to write the steps involved in finding the slope of a line. Students are free to be creative in these open-ended questions.

Another type of question is *multiple choice*. The teacher makes a list of several options for the student to choose from and each student sees a specified number of these options. One of those presented is correct and the rest are incorrect. Each student sees a different selection of options.

A third type of question *true/false*. The format is similar to the multiple-choice questions except that all of the presented options must be answered correctly (true or false) to get the problem right.

Another type of problem uses an *image map*. Students are asked a question, and instructed to click on part of an image. For example, if I present a distance/time graph and tell the student to click the section where the object is moving most slowly, the student will not get credit until they click their mouse on the flattest part of the line.

Finally, there are *numerical response* questions, which I used most. I wrote a question and provided the software with the proper formula for solving the problem. When each student is presented with the problem, every student has different numerical variables within their version. (see appendices B-V and B-VI) This type of question forces the student not only to remember information, but also to apply what they have learned.

It is also possible to make a numerical response question where no math need be done. For example, one of the questions asked students what their displacement would be on a circular track if they traveled around the track at a given speed some given even number of times multiplied by pi. Although every student had a different given variable multiplied by pi, every student's answer was zero. This question may seem strange, but I think that it shows how deeply a student understands the concept. One student may actually choose to use equations to figure out the answer and then enter "0", while another may conceptually analyze the relevant information to come up with the same answer.

When I took an online course in this format, I felt that this type of question helped me most, because when I got an answer like zero or some whole number, I looked at the problem and notes again and after a time I would see the relationship.

In any format, a teacher can't anticipate every problem every student will run into when they are working on their own. (Swift, David, 1991) In the software I used for this study, when students answered incorrectly, a hint may appear if the teacher decided to make one for that particular problem. The hint may include a formula or links to sites where the necessary information may be found. Hints may also be tuned to the answer that is entered. If a student forgets a negative sign, then the hint can be adjusted to remind the student that the sign of their answer is important.

Using email is a viable option for the online students using this software. Near the top of the screen is a button which when clicked, produces a feedback screen. The student can ask the teacher a question, make a comment, or respond to a question using this tool. The teacher response may not be instant, but the two way communication makes email flexible enough to be useful. (Porter, 1997)

Student Work

Vector analysis is central to any study of physics. Once a student knows how to approach vector problems, they have a tool they can use to solve many types of future problems. I chose to develop and document student progress using the tools mentioned above, on an internet based unit involving vectors for two reasons: It comes early in the fall so students would not be entrenched in the routines that develop in any classroom, and it is a challenging topic. Before studying vectors, students have mastered one-dimensional motion, constant (uniform) circular motion, and accelerated motion. While these topics can be difficult, they are all tied together when learning vectors. The topic uses the principles previously learned, and it forces the students to use spatial skills to solve problems. Students from past classes often recall that the vector unit was the most challenging one they encountered in the first semester of physics. Traditional in-class students receive lecture notes, see me solve sample problems, do problem sets, and typically do one laboratory activity, like using force tables.

Using this unit to study use of the internet as a teaching tool presents the teacher and the students with a high level of difficulty. If the internet format works with vectors, it will likely work with any other topic in physics.

I chose a unit on momentum as a second topic of analysis. Momentum is taught after vectors, circular dynamics, force, and energy. Momentum lessons can be made as difficult as many other topics, depending on the instructor of course. I wanted to see if the nature of the material made either vectors or momentum better suited to using online materials. If students did well with the vector unit, then they should do well with the momentum unit. Past students have commented that momentum is a less difficult topic to learn than other topics they studied, and that information contained in the earlier vector unit was in integral part of learning the momentum unit. Traditional in-class students receive lecture notes, see me solve sample problems, do problem sets, and typically do one laboratory activity, like using collision carts.

Implementation

The first two or three days of physics class were spent setting the tone for the year and finding out how much the students already know and remember from previous classes and experiences. Topics covered include significant figures, scientific notation, and dimensional analysis.

Trial Runs

On the third day of class, I announced that all students would have the opportunity to participate in a research project: "Every day for the first couple weeks, six to eight of you will go to the media center to use the internet to get class materials." Instantly, four hands went up. There was no way to be sure if their motivation was curiosity, confidence in their ability, or the desire to be anywhere other than in class. The topics covered during these first trial run days were typical of any physics class: conversions, speed, velocity, acceleration, graphing, and circular motion. Problems solved and work completed in these trial runs were not assessed as part of this study. Every student in the class was given a username and password to access the materials.

The next two weeks were spent as follows:
All students came to class on time; we briefly discussed the previous day's materials, for example, using calculators to find vector components.
The first six to eight volunteers went to the media center computers for the hour to work unsupervised.
Each day, I gave each of these students a sheet describing their responsibility for the hour. Usually, this included looking at three or four web pages and solving

one or two problems. The in-class students had to do more problems than the online students, in addition to the lecture notes and sample problems done together, as well as tactile lab activities. If an online problem proved to be quite challenging, it could easily consume a significant amount of time. Rather than focus on the quantity of problems solved, it is better to make students into flexible problem solvers. (Hilborn, et al.)

As the time went on, it became clear that the internet material wasn't for everyone. After only one visit one student asked me, "Can I never leave [for the media center] again? I need to stay here." Others reacted positively to the format. A few students repeatedly asked to go, and these students always completed the work satisfactorily.

Actual time spent on-task during these trial runs is not known. In most cases, students finished the requirements for that day. Students worked unsupervised, and could have finished their work in a short time, having time to browse the internet.

Entire Unit Online

Near the end of the first two weeks, I announced that a more involved stage of the study (involving vectors, and later momentum) was coming. Six or so students would spend either or both units using web-based materials in the

media center. Most of those participating in the first trial also worked in the second trial. Upon completion of the online unit, these students would come back to class and take the same test that the in class students would take. I tried to emphasize all of the risks, chiefly that the in class students would have the benefit of instant interaction with the teacher all hour, while the online students would have to rely on each other, the chat room, and email contact with the instructor. All students would be taking the same test at the end of the unit.
I also mentioned the possible benefits to them, like being unsupervised and the potential for having free time if they finished the work early.

I chose volunteers for this part of the study who had already shown an aptitude for using the internet format as evidenced by performance on the trial runs. This reduced my worries about whether the students I sent would really do the work. A previous study at Penn State showed that when students worked on their own using computers, accountability was a problem. In their case, the physics instructors tried to address this by having group reports at the end of class sessions. (Dimeo and Sokol, 1997)

Since I had seen the results of everyone's previous trips to the media center, I had more confidence that the ones who went for the extended online sessions would complete the requirements. On the first day of the vector unit, 12 students volunteered. I put their names in a hat and drew seven. I would have liked to have had a larger sample size, but I only had nineteen students in only one physics class. Furthermore, space in the media center was limited.

The assignment was clear: use all of the materials presented in the vector chapter and complete all of the online problems in that chapter. Using the regular class text was optional. I do not know how much use the online students made of this resource. The time frame to complete the unit was not concrete. The internet students had exactly the same number of days as the in class students. It was the in class section that would determine the test date, although I could tell the internet section students that it would likely be about two weeks.

After the vector test, (see appendix A-I) we spent several weeks on circular dynamics, force, and energy. All students were in class. There was internet material available, but only as a supplement to class materials. I have no record of how much these materials were actually used.

Upon completion of the energy unit, I again asked for volunteers to use online materials for the unit on momentum. This time there were seven volunteers, and five of these had previously worked through the internet vector section. The student who declined the second time had done poorly on the unit test, and felt that he would be better served by being in class. Again, after about two weeks all students took the same unit test (see appendix A-II), and the online students filled out a qualitative survey about their internet experience (see tables 3 and 4).

Difficulties Encountered by Online Students

Some students said that at times they felt isolated from me. If they had a question, they could not get it answered quickly. They had to ask their peers or send me an email message. I responded to all email questions after school the day I received them. Responding to questions from a larger section of students could be a significant problem for an instructor.

The chat room did not often work for any students in the media center. There could be several reasons for this, but the most likely is our school's internet server. This machine limits chat access by students to school hours. Students trying to get into the chat room got a special "access denied" page from the school's server. Lecture OnLine software is recommended to be used with the Netscape® browser, and we use a Microsoft® product on a Windows NT® server.

Twice during this study, our internet server failed. Our power supply in Beaverton is sometimes unreliable, and whenever the power fluctuated, the server crashed. Both times this happened, school was not in session, so this was not a big problem, but it did cause significant worry for me.

By design, some online problems were very difficult; some problems were difficult inadvertently. A few problems were copied from a sophomore level college physics class offered at Michigan State University. If the student answered incorrectly, a hint would appear. Several students commented that the hints were sometimes too vague and unhelpful. This was sometimes by design, so students would have to re-read the materials and formulate several different plans of attack for the problems. Likewise, sometimes the hints were too helpful, almost providing the solution. In writing the questions, it was a real challenge for me to make the hints enlightening, but not too helpful.

The unit tests included application type problems. Online students had no hands on experiences; they had only simulated experiences, while in-class students performed tactile laboratory activities. A test question may appear simple to a student who has done a related lab activity but look foreign to a student who has only had virtual activities. Conversely, a test question that is related to one of the virtual activities may be more difficult for the in-class students. For this reason, I tried to make test questions that neither leaned more toward the in-class students' experiences nor the online students' experiences.

Some students do not have internet access at home. Students with access at home could spend much more time studying the material. Also, the in-class students could view the online material anytime if they wished. For this reason, the in-class students with internet access at home had an advantage. It is not known if they exploited this advantage.

Administrative Difficulties

I often found myself worried that my students in the media center were misbehaving or just surfing the internet for fun. My concerns were dismissed by the media specialist, who routinely informed me that my kids were well mannered and always appeared to be on task.

I also worried that I had made a mistake in setting up the online problems. More than once I got email feedback from students stating that they had "tried everything" and couldn't get a specific problem right. I also must admit that more than once the students were right. On one occasion, I forgot that the software did all of its calculations in "radian" mode, so I had to account for this if I wanted students answers in degrees. The whole world can see the mistakes with the online class because I provided a generic login for the general public to use. The possibility exists that a mistake could go undetected for an extended period of time because students blindly trust the software and assume that the problem is a mistake made by themselves. (Leonard, 1997)

I also wondered if the online students were cheating on the problems. They could do this by merely waiting for someone else to get one done and ask how they did it. I had experienced this personally in an online physics class I took through Michigan State University. It used the same software I was using in my class. On the night a set of problems had to be done, the chat room was full of people asking for help. One night, I gave some vital information needed to solve a problem to another student. Later, the professor told me that this was one of the pitfalls of this software, and that he was not bothered by it because the online problems were only a portion of the course grade. Also, one could view these evens as "collaboration", which is supported by many educators. I came to agree with this atitude myself, because on any given night my online students are likely calling each other asking for help with difficult problems.

Results of Vector Posttest

Students had little to no previous experience with vectors, as indicated by the mathematically oriented pretest given before the first two week session on vectors, which yielded very poor results, typically below 25%. The posttest given to all students was the same exam and worth 46 points. The results are reported in Table 1.

Table 1

Raw scores on vector test in columns, percentages at bottom

ONLINE STUDENTS	IN CLASS STUDENTS
31	28
32	40
42	38
37	31
21	25
26	45
15	28
	26
	30
	28
	36
Possible Points=48	39
Standard Deviation=9.26	Standard Deviation=6.49
Range=15-42	Range=25-45
AVG=61%	AVG=68%

Using a t test on these results showed no statistical significance between the two groups. The t value is 1.02, and the probability of this result, assuming the null hypothesis, is 0.321. Discarding the highest and lowest scores from each group further reduces the difference between them. The standard deviations were large in both groups, possibly due to differences in interest ability.

Results of Momentum Posttest

The posttest for the momentum unit included all the questions in the pretest as well as a section of application/math questions. Five of these students had also done the vectors unit online. The results of the posttest are given in Table 2.

Table 2

Raw scores in columns, average percentage at bottom

ONLINE STUDENTS	IN CLASS STUDENTS
57	61
56	64
62	46
51	65
46	32
51	55
46	41
	42
	56
	55
	52
Possible Points=70	65
Standard Deviation=5.5	Standard Deviation=10.64
Range=46-62	Range=41-65
AVG=75%	AVG=76%

A t test performed on these results showed no statistical significance. The t value is -.0070. The probability of this result, assuming the null hypothesis, is 0.979. Again, the standard deviations were large, but the means were almost identical.

Student Opinions

Below are survey questions and responses given to the seven participants in the two week online sections.

Table 3

Question followed by number of students responding

QUESTIONS:	VECTORS	MOMENTUM	NEITHER
Which was a better section overall for you?	2	5	
Was either topic better suited for being online?	2	4	1
Which session gave you more free time?	1	5	1
Which topic do you suppose Mr. Mock spent more time on?	6	1	

I find it interesting that the students found the momentum unit easier, yet still correctly guessed that I worked more on the vector unit.

Table 4

General yes/no questions and responses

QUESTION	YES	NO	UNSURE
Was the material in depth enough?	4	3	0
Was the test suitably similar to the practice test?	5	2	0
Did the in-class students have an advantage over you?	4	1	2
Did the chat room ever work for you (even once)?	4	3	0
Was there enough material online for you to look at?	7	0	0
Did you visit the linked-to sites that were not made by me?	3	2	2
Did you view any of the downloadable movies?	5	1	1
Did the movies help your understanding?	3	2	2
Did you use the Java applets?	7	0	0
Did the applets help your understanding?	5	2	0
Should there have been more problems to solve?	3	4	0
Were the hints to the problems helpful?	5	0	2
Could online classes ever be just as good as in class sections?	4	2	1

Students participating in the momentum unit also completed a survey. Some comments were made by more than one student, but this instance is not shown.

Short answer questions and their responses

QUESTION 1:What was the best part of being in the online section?

- Work at own pace.
- Could "take a day off".
- Self motivated people could succeed.
- Group effort.
- New way to learn.
- No pencil needed.
- No written work.
- Random problem variables made it so others couldn't just get my answers.

QUESTION 2:What was the worst part of being in the online section?

- Didn't always have equations needed.
- No teacher present.
- Not enough on angular momentum.
- Not enough sample problems.
- Chat room never worked in school.
- If no one got something, there was no one to ask.

DO YOU HAVE Suggestions for improvement?

- Bigger practice test.
- More detailed examples.
- More explanations.
- More equations.

Discussion

The similarity of the results of the two sections to each other shows the usefulness of the internet as a medium for course presentation. Sample sizes were small and result ranges were large, but it is apparent that students did use the online material, as reflected by test scores. However, since the web-based learners volunteered to use the internet format, their test scores may be an indication that this group possessed personal abilities that allowed them to perform as well as their in class counterparts. (Schulman, A. H. and Sims, R. L. 1999)

Through personal contacts, another local physics teacher has already arranged to have his students access my online materials. I hope he and others will contribute to the site by sending me suggestions. If several of us get together and we each contribute the ideas that we have found to work best, the site can only improve.

I hope to offer someday an entire semester of high school physics online for credit to students in my district. Possibly, other local districts may have an interest in this option, and the State of Michigan is supporting such an enterprise.

However, putting so much independence in the hands of high school students may limit the effectiveness of any totally online course. In one mail correspondence physics course, only forty percent of those who began completed it. (Baath, 1980) This suggests to me that while an online course can be successful, some type of teacher interaction, like a recitation meeting once a week, is necessary to keep students moving in a predetermined direction. Recently, our district technology coordinator proposed that our school place materials on a website called blackboard.com, which is supported by the State of Michigan. Upon evaluation of the resources on this site, I have found the Lecture OnLine resources to be superior because the instructor can more easily manipulate course variables and page appearance. Also, the state supported site so far lacks a way to produce mathematical problems, which I feel are necessary to any study of physics.

The immediate future will see me working to improve the quality and number of pages already on the site. I am not very concerned at this point with overloading the site because students can peruse the pages as quickly as they wish. Perhaps a survey at the end of each year could help me decide how the site should evolve.

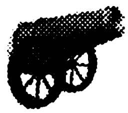
Students continued to make remarks about the materials that had been added, telling me that some of them kept visiting the site. Perhaps they will continue to drop in just to look around in the future. If the site is interesting enough to draw a bored adolescent, then it may be contributing to their interest in science in general.

I believe that putting materials online is one of the best things I have done as a teacher. It helps the students by providing them with another information source. They can also test their mastery by doing the problems. After they graduate, they can always return to the site when they eventually take physics in college.

The website has also proven very valuable to my normal teaching strategies. If I need to think of a sample problem to solve in front of class, I can visit the site and see if there is anything that is appropriate. Also, an occasional perusal of the pages helps me brush up on topics and helps me be sure I am not skipping anything important. I have even used the site to produce a few overheads rather than spend time making a powerpoint presentation. Since my school has large televisions in every room, I have also shown students around the site in class. We worked out a few online problems together, first inputting incorrect responses, then revising our plan of attack until we got it right. This could be a resource for any other physics teacher with internet access.

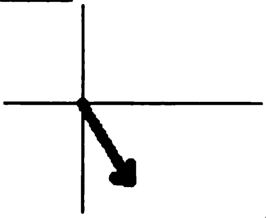
I am particularly interested in finding more Java applets because they seemed to be an important resource for students. I do not see myself learning how to program, but I intend to continue looking for useful websites with physics information because more are created continuously.

APPENDIX A-I: Web Printout of Vector Pre/Post Test



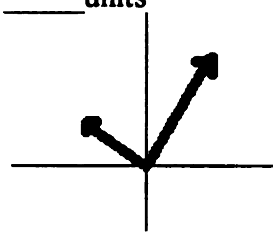
A cannonball is launched at 350m/s at an angle of 20° above the horizontal. What is its maximum height?

_____meters



A 20 unit long vector points at 300° measured counterclockwise from the +X axis. Find its Y coordinate.

_____units



Find the sum (resultant) of these two vectors.

A=50units @ + 60°
B=30units @ +140°
C=____units @ _____°

A skater on a frictionless lake hits a puck directly North at 13m/s. A breeze blows from the West and steadily accelerates the puck Eastward at 1.5m/s/s. How far will the puck be from the skater in 10seconds?

_____meters

Extra credit....

For the cannonball in problem #1, with what speed does it hit the ground?
HINT:Must consider more than just the Y velocity. _____m/s

APPENDIX A-II: Web Printout of Momentum Pre/Post Test

Billiard ball "A" is moving at 1m/s and is about to strike another stationary billiard ball "B". If ball "B" ends up going .3m/s at 20° below the +X axis, what does ball "A" do? (speed and direction)

Find momentum of a .2Kg steak knife flying at 4m/s.

Somebody drops the lid of a drum, and it rolls across a floor at 2m/s. R=.3m, m=2Kg, $I=.5mr^2$
Find its angular momentum.
Find it linear momentum.

A torque wrench has a handle that is .5 m long. I need a total of 700N to loosen a fitting. If I pull at 90° at the handle end, what minimum force must I pull with?

If the fitting from the previous problem is in an awkward spot and I have to grip the handle at .25m and at an angle of 45°, how much force must I use?

A 2m long 2Kg rod is hanging by a string from its middle. A 1Kg rock flying at 4m/s hits the end of the rod so that all of the rock's linear KE goes into making the rod spin. What is the angular momentum of the rod?
$I=mL^2/12$
(HINT: KE_{rot} is involved with the solution of this problem)

1)The unit of momentum is ...
a) m/s b)Kg*m/s c)Kg*m/s2 d)Kg*m2/s2 e)none of the above

2)If you increase the time two colliding object are in contact, the force on the objects...
a)increase b)decrease c)remains the same

3) Another way of saying "change of momentum over time"...
a)force b)acceleration c)impulse d)speed e)none of these

4) In a frictionless setting, a resting mass "2m" is hit by mass "m", which is moving at some velocity "v". If the "m" mass sits still right after the collision, how fast will the "2m" mass be going?
a).5v b)v c)2v d) can't tell from what's given

5) If wheat is dropped straight down into a train car as it rolls along (on a frictionless track), the train car will...
a) speed up b)slow down c)continue on at same speed

6)the unit of torque is ...
a)m/s b)kg*m/s c)Kg*m/s2 d)Kg*m2/s2 e)none of these

7)You push on a doorknob and put torque on a door. If you changed the angle of your applied force away from 90 degrees, the torque on the door would...
a) go up b) go down c) stay the same

8) If your are twice as heavy as a friend, you would have to sit ___ times closer to the fulcrum of a seesaw for it to balance.
a)2 b)3 c)4 d) none of these

9) A planet spins. If its radius were to become halved (all else remaining constant), it would spin...
a) faster b)slower c)same speed

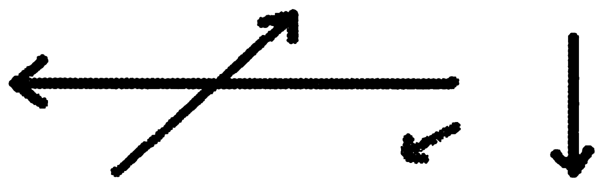
11 If you moved twice as fast, your momentum would increase ___ times.
a)2 b)4 c)no change

12 If a moving object becomes twice as heavy, its momentum would increase ___ times.
a) 1.5 b) c4 d) no change

APPENDIX B-I: Web Printout of the Welcome Page

Welcome. You have found the physics stuff. It is of course a work in progress.
Please look around and let me know what is useful (or not useful).
Suggestions are always good too.
To see everythig here, you ought to have the quicktime plugin (free) from apple.com.
Also, the chatroom works best with netscape.
RM

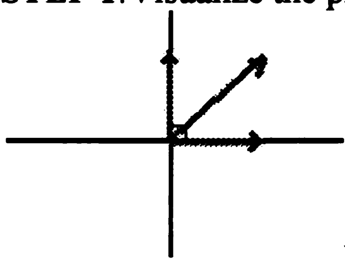
APPENDIX B-II: Web Printout of a Chapter Goals Page



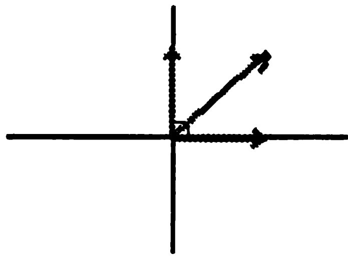
*Understand difference between vectors and scalars
*Use trigonometric functions to find vector X & Y components
*Be able to add and subtract vectors
*Understand/analyze the situation described by, "static equilibrium"

APPENDIX B-III: Web Printout of a Notes Page

Two equal forces push on a ball (we will say that each force is **1 Unit**). The forces act at 90° to each other.
What is the net force on the ball?
Do you want to just say that the answer is "2"? Don't be too hasty! If both forces were pushing IN THE SAME DIRECTION, then you would be right.
Here's what you do...
STEP 1:Visualize the problem...(a sketch is always a good idea)



Here I chose to draw the vectors along the X & Y axes. I could have drawn them anywhere, but using the axes will save me busywork later on.
STEP 2: Find the X and Y coordinates of each vector...(I call the one pointing up "A" and the other "B")
Ax=0
Ay=1
Bx=1
By=0
Now you see why I chose to draw the vectors on the axes! That step was easy!
STEP 3: Add the vectors...
Ax+Bx = 0+1 = 1
Ay+By = 1+0 = 1
STEP 4: Use the Phytagorean Theorem to find the resulting force...
1² + 1² = resultant²
so resultant = sqrt(2) = **1.42 units**
At what angle does this force act?
Look again at the drawing... hopefully your common sense is screaming at you...



The blue line is half way between the two original vectors.

Can we prove this?

We know that the X component =1 and that the Y component = 1. To find the angle in degrees above the +X axis, we can use the tangent function...

tanθ = opposite side/ adjacent side

θ = 1/tan(opp/adj) = 1/tan(1/1) = **45° H**opefully this was your common sense answer too!

NOTE: On many calculators, to get the 1/tan to happen, you would hit "shift" or "inv" or maybe "2nd". I suggest you check it out on your calculator. Test it with this: the inverse tangent of 1 is 45.

APPENDIX B-IV: Web Printout of an Activity Page

Print this page, then go to this site:
http://webphysics.davidson.edu/Applets/TaiwanUniv/collision1D/collision1D.html

Here you will find a java applet that simulates collisions.

There are several variables you can change:

MASS: change the mass of either object by right or left clicking on the mass while the applet is paused.

VELOCITY: click and drag the yellow arrow for either mass while the applet is paused.

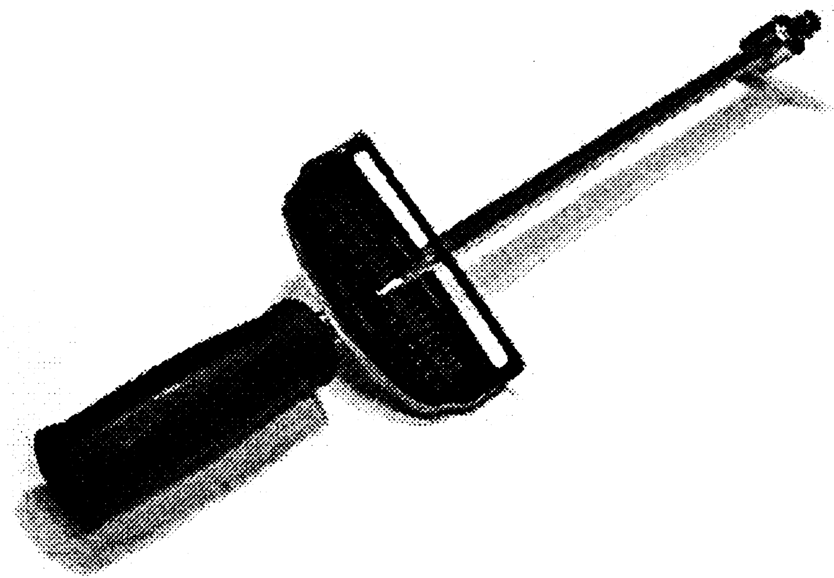
RESTITUTION COEFFICIENT: this value describes how "elastic" the collision is. set at one, all of the kinetic energy is conserved; set at zero and the masses stick together.

FRAME OF REFERENCE: there are four to choose from **the lab**; this is how we are used to seeing things (with us standing still) **mass1** or **mass 2**; see how it looks from the ball's point of view (so the ball stays still) **the center of mass**; you see things move in relation to the center of mass (is stays stationary)

EXPERIMENT 1: Click reset. Aim the velocities at each other and set them to 30 (one will be negative). Click start. Describe the motion of the center of mass (the "X")
EXPERIMENT 2: Click reset. Aim the velocities at each other and set them to 30. Change the Restitution Coefficient to zero and click start. What happens?
Describe the motion of the center of mass.
EXPERIMENT 3: Click reset. Set the velocity of one of the masses to zero. Click start. What happens upon collision? What is the speed of the hit ball? What is the speed of the previously moving ball? How does the speed of the "X" relate to the speed of the moving ball?
EXPERIMENT 4: Click reset. Set the restitution coefficient to zero. Click start. What happens to the velocity of the "X" after the collision?
EXPERIMENT 5: Click reset. Change the mass of one of the balls. What happens to the center of mass (the "X") as you change the mass?
EXPERIMENT 6: Click reset. Change the frame of reference to "m1". Make both of the masses the same. Set the restitution coefficient to "1". Click start. **NOTE**: It is very hard for people to understand how others see the world! Now you see things as mass1 would see them. Describe what you see.

APPENDIX B-V: Web Printout of a Sample of an Incorrectly Answered Question

? One previous attempt to solve.



You are using a wrench to loosen a rusted nut. Your torque Is 290 Newtons and you are pushing with 200 Newtons. If your force is applied at 60 degrees, where are you gripping the wrench (meters from nut center)?

You entered 5

This is not the correct result.

use: r = (torque)/(sin theta)(F)

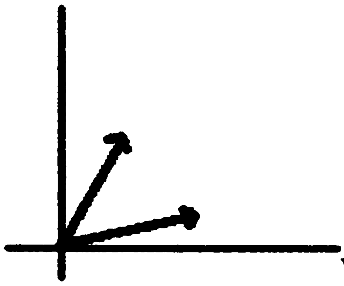
Please enter answer here (within 5 percent accuracy):

5	submit result

Previous attempts for user demo			
Date	**Log Entry**	**Remark**	**From**
Sat Jul 15 13:28:16 2000	5	-	pm553-21.dialip.mich.net

APPENDIX B-VI: Web Printout of a Sample of a Correctly Answered Problem

? 2 previous attempts to solve.



Vector A is 87 Units long, at 26 degrees above the +X axis. Vector B is 81 Units long, and aims at 84 degrees above the +X axis. Find the length in "Units" of the resultant.

You entered 141

Find X and Y components of each vector...	
Ax = 87 cos26 = 78.213	Ay=87 sin26 = 38.019
Bx = 81 cos84 = 8.424	By = 81 sin84 = 80.514
Add together the X's	
78.213 + 8.424 = 86.637	
Add together the Y's	
38.019 + 80.514 = 118.533	
Then use the pythagorean theorem to find the hypotenuse...	
the square root of (86.637 ^2 + 118.533 ^2) = 146.819	

Previous attempts for user demo

Date	Log Entry	Remark	From
Fri Jul 9 21:47:28 1999	147	-	pm613-24.dialip.mich.net
Fri Jul 9 21:47:52 1999	141	-	pm613-24.dialip.mich.net

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