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This is to certify that the
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IMPLEMENTATION OF AN ONLINE COURSE MANAGEMENT SYSTEM

By

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ABSTRACT

IMPLEMENTATION OF AN ONLINE COURSE MANAGEMENT SYSTEM

In this thesis, data were collected in order to help determine the effectiveness on physics instruction of the LON-CAPA online course management system, an open source system currently being used by high schools and universities around the world. The data were based upon several evaluations that were given over the course of two teaching units of a high school introductory physics course. The evaluations include pre test and post-tests to determine the effectiveness of online homework sets in helping students to learn the course objectives. The second evaluation was a survey administered to the students where they were able to identify which portions of the system they took advantage of, as well as the portions of the system that helped them the most.

The intention of this thesis is to provide educators with an additional resource when considering the implementation of an online course management system in their own class. There are several issues to take into account when using such a system and the tools that they bring to a classroom. Authentic assessment, mass distribution of information, and improved communication are but a few of the ways in which these systems can enhance a class. Educators should consider all of the products that are available and how it can be best implemented into their class before they commit to a single system.

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INTRODUCTION

1: THE LON-CAPA SYSTEM

In the spring of 2005, I attended a meeting with various administrators at the high school and middle school level where one of the principals said, "The parents simply want computers in the classroom. They are not even sure what they mean by it. They just know that is what they want." This is a common theme as our society continues to equate technology with progress (Johnsen & Taylor, 2002). As more impressive technology becomes readily available to the consumer each year, educators are faced with more pressure, both from outside, and within, to bring more technology into their classes. But educators need to be cautious and thoughtful when they decide to integrate technology into their classrooms. According to Dr. Gan Siowck Lee, technology should be integrated for "better teaching-learning through more effective teaching and increased teacher, student and material interaction as well as collaboration with peers and experts beyond the classroom walls." (Devi, 2001) Indeed, Kozma agrees that information management, the strong suit of computers and technology is also its most effect use in the classroom (2003). Charp concluded that not only is technology less adept at simple rote presentation of material and drill instruction, it has been shown to be less effective than traditional classroom means for these tasks (Charp, 1999). Furthermore, the integration of technology should take place within the framework of the class curriculum. Students need to view technology as the best tool for a given task within the curriculum. (Lederman & Niess, 2000). Time spent instructing students on how to use it is time lost teaching the curriculum. The oft use phrase is, "The curriculum must drive the technology. Technology cannot drive the curriculum."

This study documents the integration of an online course management system, LON-CAPA (Learning Online Network – Computer Assisted Personalized Assignments) into a high school physics class. Through the use of this system I intended to accomplish two goals. First, I wanted to increase the availability of information to my students. This was to be accomplished through increasing the ways students could access class information, and to increase the communication between students. I also wanted to use a method of authentic assessment on homework problems where students were judged on their abilities as opposed to what they observed their peers to do. Both of these goals could be met through the implementation of the LON-CAPA system.

There are a number of ways to make materials electronically available to students. Several services are available that will host websites where teachers can place class material. These have the advantage of providing additional information to anyone who happens to bring up the pages through an online search or with prior knowledge of the URL. Additionally, information is available to the students whenever and wherever they connect to the Internet. This level of access can save time, effort and money for both the students and the learning institution.

If a teacher wished for a more controlled distribution, the directory of notes could be burned onto a CD, which could then be viewed through any browser. There are several advantages to this approach. The notes are not placed on the Internet. This will prevent the usual problems that are normally associated with assignments and information that are posted on the Internet. The most common of these problems are connections of varying speed and reliability among the students' computers at home. While planning a course that is on the Internet, I believe that you must do so with the least technologically advantaged student in mind (DiBello, 2005). A brief survey at the beginning of the school year determined that this year, all of my students had Internet access and that they were familiar with the basic functions of Internet browser software and navigation through a hierarchy of content folders. This difference in computer abilities has been found to be of greater importance than the differing levels of access that students might have (DiBello, 2005: Solomon, 2002). This needs to be addressed since this "digital divide" can cause separation among the students as they divide themselves into system users and nonusers (Bobak, Casserino, Finley, 2004; Simonson & Schlosser, 2004). While some students have the advantage of a highly reliable and fast cable connection, many students are limited to older machines and dial up modems. By placing all of the notes onto a CD, the speed of the systems is dictated by the speed of the computer instead of the speed of the Internet connection, so the web pages are retrieved almost instantly. Of course there is a disadvantage as well in that the CD now becomes little more than a smaller textbook and must be with the students whenever they wish to access the information on it. Students are not able to access the notes from any machine with an Internet connection as they could if the notes were published with on the Internet. This method would also require supplemental materials be created to address any changes to the class throughout the year. Like many of the online course management systems that are available, LON-CAPA makes elements of a class available to students wherever they are able to gain access to the Internet.

The LON-CAPA system also provides teachers with several tools with which they can deliver various forms of information to their students. The first of which is a framework where teachers can create structure for their online courses. The system is set up for the teacher and students to utilize a hierarchy of folders and content that most students and teachers are familiar with from their previous computer experience using either Windows or Apple OS operating systems. The teacher also has access to the parameters that control these contents and folders. With this control, the teacher is able to determine when materials are available to students, through opening and closing dates, as well as what computers have access to the contents through their IP address, the number of attempts that students have on each problem and the numerical tolerance that the system will use in determining correct answers.

For example, a teacher may use the opening and closing dates to establish when a homework assignment is available to the students to work on, as well as when it is due. Along this same line, the teacher may also establish when the answers to a problem, or folder of problems, may be viewed by the students. This can be helpful as it allows the students to see the correct answers and use them to work out the problems that they missed. As for the IP address control, teachers can use this tool to create assessments such as online quizzes and tests that can be made only available to students in a given classroom or computer lab, as specified with a range of IP addresses.

The LON-CAPA system also provides teachers with the means of creating resources for their classes and sharing them with other teachers who participate within the system. Teachers are given an online work area called the 'Construction Space." In this area, teachers are able to code and test assessment problems and import materials from outside the system. Once the materials have been constructed, the teacher publishes the materials within the system so that they are available to the system users. The level of user access is determined by the teacher so that they may be used only within that teacher's classes, the teacher's domain, which is essentially the school where the teacher works, or system wide so that it is available to all teachers to import into their classes as they see fit. This ability to control the level of access is useful when dealing with copyrighted materials that can only be used by schools that have purchased the rights to use them (S. 487, 2001).

The problem sets, examples of which are listed in Appendices A and B, are an incredible tool in the LON-CAPA system. The problems that are developed in the system are coded in XML with some Perl elements for numerical problems. Through the coding, the teacher is able to set elements within the problem to be randomized as well as establishing parameters by which this randomization will be determined. Among these parameters are the high and low extremes for a given value as well as the "steps" by which the computer can selection a number between these extremes. For example, a user can create a random value between 3.5 and 10.5, by steps of .1, so the resultant could be 3.5, 3.6, and 3.7 on to 10.5. Since the elements within the problem have been randomized, the teacher must code or instruct the system on the correct way in which to find the answer instead of simply entering a single correct answer that applies to all the students.

This ability to randomize problems makes LON-CAPA a useful tool for authentic homework assessment. The teacher is able to either develop a set of problems or select them from the library of resources that have been created by other users. Once placed within the course, the homework sets are assigned to the students. The problems sets are essentially the same for each student, yet the individual problems are not the same for any student. So each assignment is unique in this respect. The students are not able to ask each other what the answers are to a given problem since no two students have the same problem.

Since the computer has been instructed on how to complete the problem, it takes over the role of grading the problems. As such, the students receive instant feedback in regards to whether or not they have successfully completed the problem. This feature allows the student to re-examine problems that they have not successfully completed and work them again until they are correct. Additionally, this instantaneous grading of student work results in up to the moment, real time data of the performance of individual students as well as of the class as a whole. This presentation of data is of extreme importance to the teacher as it allows the teacher to modify the lesson plan in order to address perceived weaknesses of the students before the completion of the unit.

Additionally, the unique problem sets are an effective means for encouraging cooperative learning among the students while still maintaining individual accountability on the student's part, a key role to the success of cooperative learning among groups of students (Brush 1998). Since the problems have unique answers, utilizing the same technique for finding the correct answer, the system encourages students to ask each other how to solve problems. In fact, there are several mechanisms built into the system to facilitate communication between the students. It is important that students communicate with each other in any class, but with all of the class sections participating within the same system, they are now able to communicate with any other student who is taking the class. The intersystem email allows students to communicate with the instructor privately and also allows the instructor to "broadcast" emails to the entire class. In fact, the instructor can set a priority to these emails so that the students cannot work within the system until they have acknowledged the email, at which point an automated response is sent back to the instructor.

In addition to the email, the teacher has the option to attach discussion boards to any of the resources that are utilized in the class. I chose to attach discussion boards to each of the problems so that students could pose questions about that particular problem to the class and help each other determine the answers. I also attached discussion boards to the lecture notes so that they could ask each other about any points that were brought up in the day's lecture. There were also discussion boards attached to the homework sets so that students could pose questions to the class about how the problems should be approached in general. For example, a student might ask for a refresher on how to break a velocity vector into its component vectors while working within the projectile motion unit. This asynchronous communication is especially helpful to those students who are less outspoken but still need to benefit from the interactions of students with each other and their teacher (Seng & Al-Hawamdeh 2001). As a teacher, the system provides an icon next to the items in which new posts have been created within the discussion board for that item. This allows the teacher go directly to the problems that students have asked questions about, saving time and effort.

The last form of communication that is included in the system is the online chat room. This allows students and the teacher to communicate in real time with anyone else who is active within the course at that time. This last means of communication is particularly effective for its conversation-like nature in allowing short replies and comments to be posted quickly and for all to read in an instant. However, it is only good for those who are online at that moment so it loses the "timeless" quality that the discussion boards have (Thoennessen, Kashy, Tsai, Davis 1999). Those students who are not online at that moment do not benefit from the conversations that take place on the chat room.

2: CLASS STUDY: INTRODUCTION TO PHYSICS

I used the LON-CAPA system in my Introduction to Physics course at Grand Ledge High School during the 2004-2005 school year. Grand Ledge High School is a large school of approximately 1850 students. Located just west of Lansing, Michigan, it has a large Caucasian middle class population that dominates the student demographic. My Introduction to Physics classes, of which I had three sections, consisted of eighty-six students. Sixty-six of those students agreed to take part in all or portions of the study. The demographic of students taking part in the study was very much like that which characterizes the school in general.

The addition to my classroom of a cart of fifteen Apple iBook laptop computers played a crucial role in the implementation of the LON-CAPA system. Whereas in past years, using computers in class meant scheduling time in one of the high school computer labs and moving the class to the computer lab for that day, now the students had instant access to computers when they needed them. The wireless connection to the laptop computers allowed the students to use them at their desks where they also had all their resources and materials available to them.

The Introduction to Physics course is an algebra based science class that studies Newtonian mechanics and the properties of waves. It is a full year course in which I stress the use of mathematics to reinforce the relationships that are studied in the class. The two units that I chose to use for the study were those dealing with vector addition and projectile motion.

Many instructors incorporate vector addition into one of the early units of an introductory physics course. I believe that learning about vectors and how to manipulate them is worthy of a unit unto itself. Although vectors are little more than mathematical tools, many students in my class are not yet equipped to perform operations using vectors. Developing a separate unit for vector addition works twofold to help the students. First it helps them to see the importance of learning these operations. They are not presented as a mere tool to perform some other task within the unit. Instead they are the focus of the unit. From the onset, I inform them that this a mathematics unit that describes a tool that they will use throughout the rest of the year. It also takes away the temptation to rush through this material in order to continue on with the unit. The importance of mastering the unit objectives (Appendix C) is pressed upon the students without creating a sense of urgency that might otherwise cause the students to panic.

The projectile motion unit is a sensible unit to follow the unit on vector addition. Now that the students have learned how to manipulate vectors, this unit provides them with an opportunity to use these skills. Although the objectives of this unit (Appendix D) do not deal extensively with vector addition, there is extensive work with breaking vectors into components and dealing with those components. The independence of vector components from each other becomes plainly evident when students observe the components in the vertical direction being influenced by the acceleration due to gravity while those components that are in the horizontal direction are not.

IMPLEMENTATION

1: PREPARATION

It has been found in multiple studies that online class work is most positively influenced by careful planning on the part of the teacher prior to implementation (Michael, 1998; Solomon, 2002). I first set my goals for what I wanted from the implementation of the LON-CAPA system. As mentioned earlier, I wanted to make the class information more accessible to all students and I wanted a means of assessing the students on their individual abilities. Along with the problem sets that I would be administering to the students, I developed a series of integrated lecture notes using hyperlinked web pages, a sample of which is located in Appendix E. The content was hyperlinked so that whenever an item covered in the class is mentioned in any section of the notes, clicking on that concept would send the user to the notes that dealt with that section. This gives the student control over the delivery of the course content, reinforcing the idea that this is a tool for their benefit. For example, the notes dealing with Newton's second law of motion state that force is equal to the product of mass and acceleration. Within these notes, clicking on "force," "mass," or "acceleration," will take the user to the appropriate set of notes that deal with that particular topic. This allows the user to either go back and review sections in order to refresh their memory or to jump ahead and see how the current concept will tie into future material.

The notes were written in such a way as to maintain a consistent format throughout the year. A simple header was designed to integrate a photo along with a title for each unit. The photo was often used as a launching pad for the material that was to be presented that day. The information was intentionally written in a text format rather than an outline format that lecture notes commonly take in order to encourage students to develop their own notes. Formulas and variables were placed within boxes to visually set them apart so that the students could refer to them quickly when working on assignments. At the end of each set of notes were sample problems. These problems were formatted as rollover images so that the students could see the problem and work it out on their own before placing the cursor over the problem in order to see the solution. We often went over these problems together as a class.

The notes were developed using Macromedia's Dreamweaver software. Dreamweaver is a fairly straightforward website construction program that does not require much knowledge on the user's part of Hypertext Markup Language (HTML). The program operated much like a standard word processor with the ability to drag and drop items into the work from outside sources. The user is able to simply develop a page that looks and operates as intended and the software compiles the information into HTML.

Once the notes were completed, they were uploaded into my construction space where I was able to publish them for use within the LON-CAPA system. This allowed the students to access the notes from any computer that is online. By placing the notes within the framework of the LON-CAPA system, they were further organized by units and the applicable problem sets were also placed within the same units.

It has been well established that structure is one of the most important features of any distance learning system (teleconferencing, audio conferencing, online material, etc.) that relate to student success and positive attitudes towards learning. Structure plays an important role in online coursework as it helps to define the roles of the teacher and students in the class (Johnsen & Taylor, 2002). The structure that the teacher incorporates defines the sequence of content, modes of delivery for the content as well as teacher and student interaction (Kearsley & Lynch 1996). Of the items listed, well-defined modes of interaction have been found to have a great positive impact on the students as they need to feel connected to the class, even when they are physically detached from the class (Stein, Wanstreet, Calvin, Overtoom & Wheaton 2005). With this in mind, the format of the class within the LON-CAPA system was a fairly straightforward layout that made for easy navigation in the system for both the students and me. Each unit was given its own folder so that the students could go directly into the unit on which they are working. Inside of each of these unit folders are five subfolders: *Homework*, which contained the problem sets that are graded by the system; *Notes*, which contained lecture notes; *Demos* provided a venue for QuickTime movies and audio of various pieces of the course that students could view; *Labs*, where online labs could be performed; and *Web Resources*, with various web links that students or I found useful in completing the work in the unit. Although the format of lab work and homework problems are essentially the same, the main advantage of keeping online lab work in a folder separate from the homework assignment is that it allowed me to maintain separate open and closing dates for the labs and the homework. A lab might only be open for a day or two while the homework assignment is open for the entire duration of the unit.

In addition to the preparations needed to utilize the LON-CAPA system, several assessments were developed or adapted in order to measure the effectiveness of this system. Since this is a class that I have taught several times, I already had post-test assessments to measure the students' mastery of the objectives for both the vector addition and projectile motion units. These same tests were used again as pre-test assessments in order for me to determine what the students had already learned from previous instruction. These pre-test and post-test assessments can be found in Appendix F.

I wanted to test the suitability of the system for administering in class assessments to the students. Because it was the system being assessed, I used the previously tests to measure what the students learned over the course of the unit. I used the system to administer two quizzes to the class over the course of the two units. In the vector addition unit, I developed a quiz to test the students' mastery of trigonometric functions. This quiz was intended to be administered early on in the vector addition unit. The objectives that it addressed were the very first to be introduced. Students were expected to be able to identify the sides and angles of a right triangle, as well as using trigonometric functions correctly in order find the value of a missing side or a missing angle on a right triangle. This quiz took the form of three problems that were available through the LON-CAPA system. These three problems were only open to the students during the class period and the students were only allowed three attempts to answer the problems. Once the unit was completed, I would compare the results of the quiz to the corresponding objectives on the post-test assessment in order to determine if the quiz was an indicator of what the students had learned. Appendix G contains a copy of this quiz.

In the projectile motion unit, I developed an online quiz to be administered over the LON-CAPA system that was compared with a lab-based quiz that I already had in place in the class that tested the same objectives. See Appendix H for a sample of this quiz. For the lab-based quiz, which can be viewed in Appendix I, the students were able to work in small lab groups in order to solve a problem dealing with a projectile that was launched with an initial velocity that was completely horizontal. The students were given a marble, a meter stick, a stopwatch, and a launching device that allowed to the ball to roll off the table at a consistent rate. The students were given time to determine whatever information they could about the trajectory of the ball as it rolled off the tabletop. The marble was then taken away and a target was placed on an elevated surface.

The students were then instructed to place the elevated target in the correct location so that when they were given the marble back, it would roll off the launcher and strike the target. When the students were ready, a piece of carbon paper was placed face down on the target and the ball was rolled off the launcher. The impact of the marble against the carbon paper left a mark on the target, indicating where the ball had hit. The students were then graded on their accuracy as well as the procedure that the students developed for determining the information about the flight of the marble and where it would strike on the new target.

The LON-CAPA quiz for the projectile motion (Appendix H) unit was designed to address the same objectives as the lab-based quiz. In fact, the procedure for this quiz was nearly identical except for the fact that in this case, the procedure was spelled out plainly for the student to follow, whereas the lab-based quiz also introduced the element of problem solving to the group, as they were to determine the procedure.

With the LON-CAPA quiz, a small QuickTime movie was imbedded into the problem set. Students were instructed to measure the time that the projectile was in the air. The distance that the ball traveled in the air was given to the students in the movie.

With that information the students were asked to solve a series of numerical response questions, similar to the homework sets shown in Appendices A and B. As a teacher, a homework set was issued to my account as well. Those are the actual problems that are included in the appendices. Each student had a set of the same problems; only the numerical elements within those problems were different, as described in the introduction.

The last assessment that I developed was a survey, which gave the students an opportunity to express their attitudes about the LON-CAPA system and how it was implemented in my class. A copy of this survey is located in Appendix J. The survey consisted of a series of short answer and scaled response questions pertaining to each of the aspects of the LON-CAPA system described in the previous section. Students were also given an opportunity to freely respond to what they felt were the strengths and weaknesses of the LON-CAPA system.

2: VECTOR ADDITION SUMMARY

Table 1 describes the subject being taught and a reference to the LON-CAPA lecture notes for that day. The objectives are numbered according to the objectives listed in Appendix C. Column four indicates whether there were corresponding LON-CAPA homework problems for those objectives and the *Features* column lists any addition LON-CAPA resources mentioned in this study.

Week / Day	Topic /	Objective	LON-CAPA Problems	Extra Features
Week 1 Day 1	Vector Addition Pre-test	NA	NA	
Week 1 Day 2	Trigonometric Functions Lecture Notes 2-1	3	No	
Week 1 Day 3	Vectors Lecture Notes 2-2	1, 2, 5	Yes	
Week 1 Day 4	Components Lecture Notes 2-3	6, 7	Yes	
Week 1 Day 5	Quiz: Trigonometric Functions	NA	NA	LON-CAPA administered quiz
Week 2 Day 1	Vector Addition Lecture Notes 2-4	3, 4, 5, 6, 7, 8	Yes	
Week 2 Day 2	Vector Addition in class problem set	NA	No	
Week 2 Day 3	Inclined Surfaces Lecture Notes 2-5	5, 6, 7, 8	Yes	
Week 2 Day 4	Equilibrants Lecture Notes 2-6	4, 5, 8	Yes	
Week 2 Day 5	Vector Addition Quiz (Not part of study)	NA	NA	
Week 3 Day 1	Review for post-test	NA	NA	
Week 3 Day 2	Review for post-test	NA	NA	
Week 3 Day 3	Vector Addition Post-test	NA	NA	

Table 1: Summary of topics covered in the Vector Addition unit

3: VECTOR ADDITION WEEK ONE

The first day began with a pretest (Appendix F) to establish prior knowledge of the material. This assessment was a means to measure the effectiveness of the tools that I was incorporating into the class by determining what the students already knew from previous instruction. The homework set for the vector addition unit (Appendix A) was also opened at this time. The students were informed that the problem sets would be due at the end of the unit. I also reminded them that the even though I usually made it a point to try to get online between 8:00 and 9:00 at night and would be present in the chat room to answer any questions, their best course of action was a post questions on the discussion board so that anyone who accessed the problem would benefit from the responses.

On the second day I introduced the first section of the vector addition unit, which dealt with simple trigonometric functions. Since much of what goes on in an introductory physics course deals with working with the components of objects that are acting at an angle, it is important for students to understand these functions in order to break entities into their components or to combine components in order to determine a vector's magnitude and direction. With only about half of the students taking Functions, Statistics and Trigonometry (FST) concurrently with physics, many of them had never been exposed to sine, cosine, and tangent functions. I explained to the class that I would treat this material as if it was new to the entire class, and those who already knew this material could treat this section as a review. Based on the feedback from the students, I concluded that many of them were quite comfortable with the material.

Day three introduced the concept of a vector. We began with a discussion of what a vector represents and how vectors behave. I also used examples of adding vectors graphically so that they could start to get an idea of how they interact with each other. Many of these examples were already incorporated into the online lecture notes. Having the examples written into the notes provided an additional aid to keep me from forgetting to mention them in a lecture period.

The following day we discussed vector components. I reminded them of our conversation from the day before. Even though on the surface components may seem ancillary and time consuming when using them to add vectors, in the upcoming units there will be many cases where the components seem more important than the actual vector, itself. The concept of component axes was also introduced. There were a couple of examples of component axes written into the lecture notes. Here the students could see that what occurs along one component axis has no effect on what is happening along the other axis. Students seem to struggle with this concept, as it requires them to determine which axis system is appropriate for a given situation. I also made it a point to announce to the class that the following day's quiz would be administered over the LON-CAPA system.

On the fifth day, the students were administered a quiz via the LON-CAPA system (Appendix G). They were given the hour to complete the quiz. The time was more than sufficient as every student in all three class sections completed the quiz well before the class period ended. There were two problems that occurred with the quiz as it was administered. Both of these problems as their solutions are discussed in the DISCUSSIONS section of this paper.

4: VECTOR ADDITION WEEK TWO

The next section to be taught was vector addition. I did everything I could to impart upon the students the importance of this single section. I pointed out to them that I had even switched the background color of the LON-CAPA online notes to a bright yellow, instead of the normal white, to reinforce the importance of learning this procedure. The procedure that I teach for adding vectors is broken into three steps: 1) Break the vectors into their components; 2) Combine the like components; 3) Recombine the resultant components in order to create the resultant vector.

On the second day of week two, the students were given the class period to work on a problem set for some additional practice in vector addition. The problem set was provided in the ancillary materials from the textbook publisher. As I handed out the problem set, I again stressed to the students how important it was that they learn the process for vector addition. I tried to explain to them that their ability to succeed in the next few units hinged upon their ability to master this skill. Even after this brief talk, most of the students still opted to work on their LON-CAPA homework set in lieu of working on the vector addition problems.

On day three we discussed inclined surfaces. I alluded back to the prior section pertaining to components, reminding them that the only stipulation in creating a system of components is that they be orthogonal to each other. Even though the vast majority of component systems appear to be horizontal and vertical, even those that are oriented East-West, and North-South are often drawn to appear horizontal and vertical. In the case of inclined surfaces, it is most advantageous to orient the components so that they are either parallel or perpendicular to the inclined surface.

Week two, day four was when we discussed the last topic of the unit, equilibrants. I explained to the class that the section dealing with equilibrants did not introduce anything new into the course, since an equilibrant is a vector that brings the vector sum to zero. As such, it is identical in size to the resultant of a set of vectors and it has the opposite direction. Its components have the same size as the components of the resultant, but their signs are reversed. I stressed to the students that if they discipline themselves to stick to the procedure that I taught them in the vector addition section, then all they have to do is switch the signs on the resultant components to produce the equilibrant: the same procedure that produces the resultant can also produce the equilibrant.

At this point I felt that we had covered vector addition to the point that on Friday, administering a vector addition quiz was appropriate. Once the quiz was completed, the students were given a small handwritten problem set to work on. The problems all involved breaking up vectors on an incline into their components and were intended to give me a base for further class discussion on the topic.

5: VECTOR ADDITION WEEK THREE

The first two days of week three were spent reviewing for the post-test, which would be administered on day three of that week. The students were given a handwritten collection of problems that covered the main objectives of the unit. The day that the problems were handed out the students were not given the option to work on their LON-CAPA problem set that I had assigned at the beginning of the unit (Appendix A). The following day was spent in its entirety reviewing the solutions to the review problem set.

I was away at a conference the day that the test (Appendix F) was administered to the students. When I returned the next day, I found that most of the students were not confident in how they had performed on the test. Several students expressed concern that had I been there, I would have been able to answers various questions of clarity on the test.

6: PROJECTILE MOTION SUMMARY

As with Table 1, the Table 2 describes the subject being taught a reference to the lecture notes for that day. The objectives are numbered according to the objectives listed in Appendix D. Column four indicates whether there were corresponding LON-CAPA homework problems for those objectives and the *Features* column lists any addition LON-CAPA resources mentioned in this study.

Week / Day	Topic /	Objective	LON-CAPA Problems	Features
Week 1 Day 5	Projectile Motion Pre-test	NA	NA	
Week 2 Day 1	Data collection for "fly ball" projectile project	NA	No	
Week 2 Day 2	Expectations for write up of "fly ball" projectile project	NA	No	
Week 2 Day 3	Horizontal Launchings Lecture Notes 3-1	1, 2, 3, 4	Yes	QuickTime movie demo
Week 2 Day 4	Hours 2, 3: LON-CAPA set Hour 6: Lecture Notes 3-1	NA 1, 2, 3, 4	NA Yes	
Week 2 Day 5	Hours 2,3: Lab-based Quiz Hour 6: CAPA-based Quiz	NA	No	Lab-based Quiz CAPA-based Quiz
Week 3 Day 1	Hours 2,3: CAPA-based Quiz Hour 6: Lab-based Quiz	NA	No	CAPA-based Quiz Lab-based Quiz
Week 3 Day 2	Hours 2,3: Angled Launching Lecture Notes 3-2 Hour 6: CAPA-based Quiz	1, 2, 3, 4, 5 NA	Yes No	 CAPA-based Quiz
Week 3 Day 3	Varied Initial and Final Heights: Lecture Notes 3-3	1, 2, 3, 4	Yes	
Week 4 Day 1	CAPA Homework Set	NA	NA	
Week 4 Day 2	Review of Class Materials	NA	NA	
Week 4 Day 3	In Class Work on "Fly Ball" Project	NA	NA	
Week 4 Day 4	Projectile Motion Quiz	NA	NA	
Week 4 Day 5	Review for Post-test	NA	NA	
Week 5 Day 1	Projectile Motion Post-test	NA	NA	

Table 2: Summary of topics covered for the Vector Addition unit

7: PROJECTILE MOTION WEEKS ONE AND TWO

Because of cold weather, the class took the projectile motion pretest (Appendix F) instead of collecting data for the "fly ball" projectile motion project. In addition to this, I announced the opening of the projectile motion problem set (Appendix B) to the class. So on Monday of week two, we collected data for the "fly ball" projectile project. I took the students out to the baseball diamond to hit fly balls. Each student took a turn at the plate and took a few slow pitches of a tennis ball to swing at. The distance that the ball traveled, as well as the time that they were in the air were recorded for each of their hits. Over the course of the unit, the students would learn how to break down the motion of the ball. Breaking up the flight into ten intervals, the students would examine with a series of graphs and illustrations what was happening to the position, velocity, and acceleration of the ball until it hit the ground.

Expectations for this project were shown on a video made by last year's students that illustrated the requirements of the write up for the project. The video was far more entertaining than informational, so from there, a large amount of time was spent going over the requirements with the class. I explained to them that they would complete this project on their own time, outside of class. They were given only one class period in order to finish up some pieces of the write-up at the end of the unit when it was due in addition to some occasional "down time" when they could work on the write-up as well.

Wednesday we reviewed vector components. Making use of the hyperlinked notes, we were able to visit the pages that pertained to components. We also started the online lecture notes for the day's material. The notes included a small QuickTime movie that illustrated the principle that gravity only acts in the vertical direction. The film was a shot of a ball rolling horizontally off of a tabletop and striking the ground below. The movie stops for a few seconds at each tenth of a second as the ball travels through the air. The movie was projected onto the whiteboard at the front of the room and as the ball paused I marked the position of the ball on the board. We measured the positions of the ball at each interval in both the horizontal and vertical directions. It was easy to see from the measurements that the ball traveled at a constant rate in the horizontal direction as the distance increased at regular intervals. In the vertical direction we applied the formulas that the students had learned in the first unit dealing with free fall to solve for acceleration and confirmed that the ball acceleration of 9.8 meters/second^2.

At the end of the week, the classes were scheduled to take the lab-based quiz (Appendix I). The quiz was essentially a physical reenactment of the movie that they had seen the day before. An assembly that had occurred earlier in the week had thrown the sixth period class out of sync with the other two. As such, I decided to administer the LON-CAPA projectile motion quiz (Appendix H) instead. Since the objectives tested, and the overall procedure to be followed was intended to be the same for both quizzes, they could be administered in either order.

8: PROJECTILE MOTION WEEK THREE

The week began with the students completing the LON-CAPA and lab-based quizzes (Appendix I), followed by the second of three lectures for this unit, concerning the launching of an object at an angle. In this section, I did everything that I could to stress the procedure that was used to solve these problems over any of the particulars of the sample problems. Most of the questions that the students asked concerned whether or not learning the information in this section would enable them to complete all of the remaining problems in the LON-CAPA homework set. I informed them that after the next day's lecture, they would have all the necessary information to complete the LON-CAPA homework set. The students were assigned a small problem set from the textbook to reinforce what they had learned. However, once they were free to work, the majority of the students acquired computer to work on the LON-CAPA homework set.

The last of the three lectures fell on the Wednesday before the Thanksgiving break. I presented it as an extension of the previous day's lecture, launching at an angle. In this case, the object landed at a height other than that from which it was launched and the symmetries that existed when the object returns to its original height no longer apply. Before leaving for the extended weekend, I reminded the students of the impending due date for the LON-CAPA homework set and that I would make an effort to be online during the evening hours while I was at home over the weekend.

9: PROJECTILE MOTION WEEKS FOUR AND FIVE

After Thanksgiving break the students were given the hour to work on their CAPA sets in class. This gave me the opportunity to answer any questions the students might have about any of the problems that they had been working on in the homework set. Since many of them had very similar questions about the same problems, I was able to put my own problem set (Appendix B) up on the overhead in order to use it as an example for the classes.

Looking through the system generated feedback I noticed that many of the students were having difficulties with the problem that involved solving for multiple variables. Before class on Tuesday, I worked out an example problem that involved using two equations to solve for two unknowns. The volleyball problem that had so many students concerned actually makes use of three equations in order to solve for three unknowns. I had expected that the students would be able to take the example as a reminder of a procedure that they had learned in algebra and apply it to three unknowns. Once again, much of what I stressed in these units dealt with learning the procedure and their rationale so that they can better apply these procedures in the future.

Students were given a day for working on their projectile motion projects (see Projectile Motion Weeks One and Two). They were to spend the hour working out the last of the calculations and graphs so that they need only complete a few pieces at home to finish the project. Many of the students opted to work on their LON-CAPA homework sets (Appendix B) during the hour instead of working on the project

The last quiz for the unit was taken the next day. It was followed by a handful of review problems to better prepare the students for the test that was to come up in a few days. Several students approached me about coming in after school that day for some additional assistance. I stayed after with those students until about five o'clock in the evening.

The "Fly Ball" projects were due at the end of this week. I had announced to the class that I would post the answers to the review questions and that I would answer questions about the review or last minute questions about the projectile motion project. After classes were over, stayed in my classroom again until 5:00, helping students with their few remaining CAPA problems, which were due at midnight. The unit ended with a test that was administered on the final day. After finishing the test (Appendix F), the students were asked to complete a copy of the survey found in Appendix J concerning their use of and attitudes toward the LON-CAPA system. I neglected to mention that they needed to write their names on the survey and so I was only able to identify twenty-nine surveys from students who agreed to be part of the study.

EVALUATIONS

1: PRE-TESTS AND POST-TESTS

The mastery of objectives (Appendixes C and D) was measured using pre-tests and post-tests for each of the units. The pre-tests were administered at the beginning of the unit to establish what the prior knowledge that the students had. The post-tests were administered at the end of the units to determine which of the unit objectives the students had mastered. Table 3 illustrates the results from those tests for the vector addition unit.

Objective	Pre-test Results	Post-test Results
1: Vector Properties	41%	86%
2: Scalar Properties	35%	81%
3: Trigonometry	22%	84%
4: Commutative Property	55%	86%
5: Effect of Direction	21%	38%
6: Orthogonality	38%	73%
7: Vectors in Same Direction	27%	49%
8: Algebraic Addition	0%	32%

Table 3: Percentage of students that successfully completed the objectives (Appendix C) of the pre-test and post-test for the vector addition unit. (n = 66)

A paired t test of the data in Table 3 yields a probability of 0.000 of accepting the null result, suggesting that the students' comprehension of the objectives for the vector addition unit increased after the instruction in the unit.

Objective	Pre-test Results	Post-test Results
1: Independence of Components	46%	89%
2: Gravitational Acceleration	13%	91%
3: Horizontal Motion	5%	86%
4: Instantaneous Velocity	0%	23%
5: Projectile Symmetry	0%	58%

Table 4: Percentage of students that successfully completed the objectives (Appendix D) of the pre-test and post-test for the projectile motion unit. ($n = 66$)

A paired t test of the data in Table 4 yields a probability of $p = 0.007$ for accepting the null result, once again leading me to believe that there is a relationship between the students' mastery of the objectives for the projectile motion unit and their instruction during that unit.

There is a sign difference amount of prior knowledge coming into the vector addition unit compared to that of the projectile motion unit. This is likely due to the fact that much of the material in the vector addition unit is covered in both the Geometry and Functions Statistics and Trigonometry classes that many of the students had completed prior to taking this class.

2: EFFECTIVENESS OF THE LON-CAPA PROBLEM SETS

The effectiveness of the LON-CAPA problem sets in helping the students to meet the objectives (Appendix C and D) of the vector addition and projectile motion units was evaluated. This evaluation is a comparison between the students' pre-tests and post-tests as related to their performance on the LON-CAPA problem set elements that addressed that same objective.

Whether a student had learned a given objective was determined by comparing the results of the student's pre-test against the post-test question of the same objective. If the student failed to successfully master the objective on the post-test, then it must be concluded that the student did not learn that particular objective. In this portion of the evaluation I have also eliminated those students who showed mastery of the objective on the pretest. I assumed that those students already had sufficient knowledge of that objective and did not learn that objective over the course of the unit. The only students that have been considered in this analysis are those who displayed mastery of the objective on the post-test and not on the pre-test. The number of students who fit these criteria is shown in Table 5 and Table 6 of the following sections.

The performance of the students who learned the objective was compared against that of the students who did not learn the objective. Students who did not master an objective on the post-test are considered to have not successfully completed the objective. Just as in the comparison above, how the student fared on the corresponding LON-CAPA problems was measured against their success on the post-test evaluation.

3: VECTOR ADDITION HOMEWORK SET

There were eight measured objectives in the vector addition unit as described in Appendix B. The Table 5 shows the average performance of students on the problems that met each of the objectives. The performance by the students on the LON-CAPA

Vector Addition homework set was nearly the same regardless of whether or not they had mastered the objective after instruction. The correspondence of the student's performance on the LON-CAPA homework set to their learning of the objective was determined through a paired t Test where correlation was determined at a p value of .05. The results of the Student t Test yielded p = .069. With these values as close as they are, I can not confidently say that the performance on the LON-CAPA homework set is any sort of indicator of the student's performance on the post test assessment. Although this did not seem out of the ordinary so nearly all the students received full credit or close to it on the homework set.

Objective	Performance for Learned Objectives	Performance for Not Learned Objectives
1: Vector Properties	93.1% (28)	87.5% (9)
2: Scalar Properties	100% (32)	100% (11)
3: Trigonometry	98.9% (32)	75% (8)
4: Commutative Property	100% (26)	75% (7)
5: Effect of Direction	100% (15)	92.8% (38)
6: Orthogonality	100% (21)	100% (14)
7: Vectors in Same Direction	100% (16)	90% (30)
8: Algebraic Addition	88.9% (18)	93.9% (42)

Table 5: Student Performance on LON-CAPA Vector Addition Homework Set
In parenthesis are the numbers of students who fit the criteria.

The subjective trend in the data implies that the students' performance on the LON-CAPA homework set was indicative of whether or not they learned the objective. In the first seven objectives, the students who learned the objectives performed as well or better than those who did not meet the objectives. It was only on objective 8 that the students who did not learn the objective performed better and the difference in their scores was only 4%.

4: PROJECTILE MOTION HOMEWORK SET

For the projectile motion unit, there were only five measured objectives. Table 6 shows that the average score on the LON-CAPA problem set for the students who had not mastered the objectives was slightly higher than the mean score for those students who had mastered the objectives. When examined with a paired t test, the data from Table 6 produced a p value of .808 With such a high probability of the null result, I cannot conclude that a student's performance on the homework set is any indication of the student's performance on the post-test assessment in this unit.

Objective	Performance for Learned Objectives	Performance for Not Learned Objectives
1: Independence of Components	89.3% (29)	96.3% (7)
2: Gravitational Acceleration	84.6% (47)	93.8% (6)
3: Horizontal Motion	91% (50)	100% (8)
4: Instantaneous Velocity	82.8% (15)	79.9% (46)
5: Projectile Symmetry	92.4% (36)	76.4% (25)

Table 6: Student Performance on LON-CAPA Projectile Motion Homework Set
In parenthesis is the number of students who met the criteria.

In this case, the data were less conclusive than in the vector addition homework. For objectives 1, 2, and 3, the students who did not learn the objectives performed better on the LON-CAPA homework set than those students who did learn them.

5: EFFECTIVENESS OF THE NUMBER OF ATTEMPTS

I also wanted to determine the effectiveness of the feedback that the LON-CAPA system provides for the students. I analyzed those LON-CAPA problems that the students did not successfully complete. These problems were chosen because they indicate a student's willingness to stick with a problem until it is correct. I looked only at the number of attempts that the students made in order to see how effective it had been for those students that made multiple attempts. I compared students who had achieved the objective on the post-test against those students who had not mastered those objectives. The same criteria were used in this evaluation as in the Evaluations, Section 2: Effectiveness of the LON-CAPA Homework Set in order to determine whether the student had learned the objective.

In the vector addition assignment there were three problems that met these criteria. Of those three problems, students who learned the objective averaged 8.22 attempts per problem, while those students who failed to meet the objective averaged only .933 attempts. Whereas this seems like a large difference at first, the Student's t Test produced a value of $p = .14$. Statistically, this result is not enough to say with any certainty that there is a correlation between the number of attempts and the learned objective. Looking at the data though, it seems obvious that those students who eventually succeeded in mastering the objective made nearly nine times more attempts on the problems that they were not successful at as those students who did not master the objective.

The results of the analysis of the projectile motion homework set showed similar results to those the vector addition homework. In this case there was a greater number of samples as thirteen problems met the criteria. For these thirteen problems, students who learned the objective averaged 1.15 attempts per problem. On the same problems, those students who did not learn the objective averaged only 0.67 attempts on each problem, slightly more than half that of the students who had success on the objective. However, the value yielded in the paired t test was $p = .15$ This too was not enough to say with any certainty that there is a correlation between the number of attempts and the level of success achieved on the objective.

6: EFFECTIVENESS OF QUIZZES

In my classes, I use quizzes as a means of gaining feedback as to whether students have mastered the most recent material. The analysis of the quizzes was a bit simpler than that of the LON-CAPA homework sets. For the sake of this evaluation, I wanted to know if the students who successfully mastered the objectives on the quiz also mastered them on the post-test assessment. I compared the objectives that the students completed or missed on the quiz to the corresponding objectives on the post-test assessment.

With the vector addition quiz that was administered on the LON-CAPA system, the results of the quiz very closely matched the results of the post-test. In fact, I found that of the students who successfully completed the objective on the test, their scores were 98.3% on the quiz, which measured only that objective.

In the case of projectile motion quiz, for the lab-based quiz there was a fairly high correspondence between the objectives on the quiz and those of the test. 81.2% of the results on the quiz were the same as those on the test. On the other hand, the results of the CAPA-based quiz did not match up nearly as closely as those of the lab-based quiz. On the LON-CAPA based quiz, only 43.2% of the objective results matched those of the post-test. This would lead one to believe that the lab based quiz was a better indicator of what the students knew at the time of the quiz than the LON-CAPA quiz.

7: STUDENT SURVEYS: OVERVIEW

At the end of the second unit, I administered a survey (Appendix J) that addressed the ways in which the students made use of the LON-CAPA system. The survey allowed for me to see what areas I, as an instructor, should place a greater effort in order to address the needs of the students. The first questions addressed which parts of the LON-CAPA system were used the most. The results of that question are in Table 7. Twenty-nine students completed the survey. Since they were able to check more than one feature, the total percentage exceeds one hundred percent.

Sections of the LON-CAPA system	Percentage of students who frequently used that section
Lecture Notes	72%
Daily Assignments	31%
Homework Assignments (Online)	100%
Calendar	7%
Labs	14%
Discussion Boards	69%
Web Resources	24%

Table 7: Results of the question, "Which sections of the LON-CAPA system do you use frequently?"

8: ONLINE LECTURE NOTES

Because of the time spent preparing the online lecture notes, there were several survey questions that asked about online notes. Of the students who participated in the survey, 72% of them stated that they frequently viewed the online lecture notes. The survey also asked the students to rank how useful they found the lecture notes. They were given a five point scale with "5" being "very useful", "3" being "somewhat useful" and "1" being "not at all useful." The results are shown in Table 8.

Rank	Number of Students
5 – Very Useful	24 %
4	34 %
3 – Somewhat Useful	28 %
2	7 %
1 – Not At All Useful	7 %

Table 8: Results of the question, "Do you find the notes to be useful?"

With 86% of the students claiming that they found the notes to be at least somewhat useful, this data seems consistent with the first question in which 72% claimed that they viewed the online lecture notes frequently. When asked how the lecture notes were used, the student responded as shown in Table 9.

Use	Percentage of Students
Supplement to in-class lecture notes	31%
Reference for online homework	48%
In lieu of written notes	14%
Do not use them	7%

Table 9: Results of the question, "How do you use the online lecture notes?"

9: ONLINE HOMEWORK SETS

Referencing back to Table 9, it comes as no surprise that all of the students reported using the online homework sets since these problems are counted towards their overall class grade. As this portion of the system involves problems that are required for the student's grade, I had to take into account that the students have different levels of Internet access. The LON-CAPA system has a print feature that generates simple, two column .PDF documents that can be read by Adobe Acrobat, Acrobat Reader, a freeware product, or Apple Preview and printed from any of these applications as well. At the beginning of the year, I instructed the students on how to produce these documents. I also advised those students with slower Internet connections to take advantage of this function and print out their sets at the beginning of the unit. This allowed them to work on the problems at their leisure and then enter their results online in less time. I found that many students followed this advice regardless of their Internet connection, as they simply preferred to read off a printed page instead of from a computer screen. This was evident on the survey since 41% of the students claimed to print off hardcopies of the homework sets.

10: COMMUNICATION

The students' responses regarding the effectiveness of each of these forms of communication present within the LON-CAPA system are shown in Table 10.

Communication	Very Effective	Somewhat Effective	Not At All Effective
Email	5	12	12
General Discussion Board	15	14	0
Homework Discussion Board	18	9	1
Lecture Note Discussion	14	10	5
Chat Room	11	16	2

Table 10: Student responses to the effectiveness of the different forms of communication (29 student responses)

The results indicate that most students favored the use of the discussion boards. I was not surprised to see that the email was not found to be nearly as effective, as I had pressed upon them the advantage of using the discussion boards so that everyone could see their questions and help out with the answer. I was surprised to see how effective the students found the lecture note discussion boards to be since there was very little if anything posted on the discussion boards that were attached to each day's lecture notes.

It is possible that many students misinterpreted the question to be related to the effectiveness of classroom discussions during the lecture

11: STRENGTHS OF THE LON-CAPA SYSTEM

The last portion of the survey asked the students to address the strengths and weakness of the LON-CAPA system from a their point of view. I felt that this section was of great importance, as the students need to feel that these tools are there to aid in their learning. Huang found that student perception is linked to academic success in a class (2002). Technology should not be brought into a class simply for the sake of introducing technology; it must be driven by the curriculum of the course. The responses that the students had to this question are listed in Table 11.

Strengths	Number of students
Instant feedback on problem sets	11
Cooperative effort between all students	6
Open communication with all students	5
Motivates students to keep working	4
Provides more practice for tests	3
Open at all times / Better accessibility	2
Easier to take notes	1

Table 11: Students reported strengths of the LON-CAPA system

I found it encouraging that the most reported strength was the fact that the system provides instant feedback to the student regarding whether they have completed the problem correctly. I had expected that this would be the one aspect of the system that would not be as advantageous to students with slower Internet connections, as they are also the ones who frequently print hard copies of their problem sets and then enter all of their answers at a later time. I encouraged the students to use whatever free time they had at the end of a class period to log onto the system and check their answers. I explained to them that they needed to provide themselves with enough time to make corrections for any of the incorrect problems.

Students also replied that the responses from the system motivated them to keep working on the problems. In general, my students are not complacent. They are quite academically motivated. For them to be given the opportunity to make corrections on a problem is a great advantage. By making the homework set a significant portion of their grade, the students are able to see large changes in their grade by successfully completing the homework set. Thus, the feedback provided by the system allows them to track their progress and address those parts within the unit where they are weakest. I was not surprised that a similar number of students replied that the system allows them to better prepare for a test at the unit of a unit.

The second and third largest positive responses pertained to the communication tools within the system and the fact that the randomized problem sets promoted cooperative learning between the entire class of students. I address these two issues together as I believe that the cooperative learning that takes place between the students is an extension of the communications that are inherent in the system. It's rather promising that many of them realized the advantages in using that communication to aid each other.

I did find it curious that only one person responded that the system makes it easier to take class notes. This seems a contradiction to the number of students who replied that they found the online lecture notes to be useful to them. Also, there was a large number of students who had claimed that they either used the online lecture notes to supplement the notes that they took in class or in lieu of taking written notes all together. It could be that students who used the online lecture notes instead of taking notes did not respond that the system made it easier to take notes since they did not actually take any notes of their own.

12: WEAKNESS OF THE LON-CAPA SYSTEM

Table 12 shows the most frequent student responses in regards to the weaknesses of the LON-CAPA system.

Weakness	Number of Students
Not enough feedback on wrong answers	6
Internet access varies for students	4
Not enough tolerance for correct answers	3
Problems are harder than in class problems	3

Table 12: Students reported weakness of the LON-CAPA system

Although students appreciated the feedback that they received from the system, several of them cited "Not enough feedback" as a weakness of the system. I believe that there is a confidence issue at the root of this response. In speaking with the students and working with them on problems that they had yet to correctly solve, I found that there were different approaches taken by students of differing confidence levels. Students who believed that they could complete the work seem undaunted when they received feedback from the system saying that their work was incorrect. Often times they would look over what they had done and scan for any mathematical errors first. If they saw nothing, then they would begin to rework the problem with a different strategy or review their notes in order to see if they had missed something along the way.

On the other hand, students who were struggling with the material often felt defeated when they would find out that they had not correctly solved a problem. If they did not think that there was any other way to complete the problem other than the method that they had used, they felt that they could not successfully complete the problem. Frequently, these students would come to me for help after only one or two responses from the system indicating that their work was incorrect. Occasionally, they had made a mathematical error, but more often than not I found that they had implemented a strategy that could not produce a correct solution to the problem.

The LON-CAPA system does provide a means of giving "hints" to the students. These hints are usually simple statements along with feedback to the student. As such, they are usually quite general and are reminders of what strategy should yield a correct answer to the problem. The problem author must program these hints. Since I had imported problems from within the system, I was not able to amend them in such a way as to make hints available to students.

Three students addressed the issue of tolerance. This was a very specific problem in the units being taught. The teacher has the ability to set the numerical tolerance for what is considered to be correct answers by the system. This is done within the *parameters* page of the system and the tolerance is set as a percentage of the correct answer. I set the tolerance in the homework at one percent. It has been my experience that rarely are students off by more than this as a function of rounding or not rounding a number. The issue came up in problems where the author had set the value for the acceleration due to gravity at 9.81 m/s^2. As a habit, I use 9.8 m/s^2 in my class. As a result, most of my students do the same thing. Since .01 is more than one percent of 9.81, students who performed the work correctly often ended up with answers that were outside of the given tolerance accepted by the system. This was remedied by posting a message on the discussion board that 9.81 m/s^2 needed to be used for the acceleration due to gravity for those problems.

Although my strategy was to implement the LON-CAPA system into my class with the least privileged student in mind in terms of Internet access, the students still brought up the issue of inadequate access at home as a weakness of the LON-CAPA system. Even with the techniques and strategies that I discussed with the students for maximizing the resources that were provided for them, those students with faster Internet access were able to better utilize the feedback and communication features of the system.

For example, I would often log into the system and open the chat room to see who was currently working on the problem sets and if there was anything I could help them with. Obviously I could not provide that same level of service to students who were working off their hard copies and entering their answers at a later time. And those students who did log on with a slower connection such as a standard dial up connection found it difficult to participate in online discussions, as their inputs were not as timely as those of students with faster connections. In this respect, they seemed to “lag behind” the conversations that people were having.

The issue of problems sets (Appendices A and B) being harder on the system than those problems that I assigned to them as daily work out of the textbook is more of a perceived issue with my curriculum than with the LON-CAPA system. The level of difficulty of the LON-CAPA problems is where I believe they should be in this class. Many of the problems require the students to incorporate what they have learned in previous units as well as mathematical techniques that they have learned in their prerequisite math courses in order to successfully complete the problems. The problems that are published in the textbook and in the ancillary materials are generally more straightforward in nature. These problems only test the student's ability to utilize the most recent topic and the solution rarely involves the use of any skills beyond those that were learned in a beginning algebra course. My response to the students when posed with these complaints is that the work that they do in the LON-CAPA homework sets is more indicative what I feel they should be able to complete in order to meet the objectives of the course. Regardless of the small number of responses, this is still an important issue as perceived separation between instruction and assessment can have a potentially negative impact on the class (Gulikers, Bastiaens, & Kirschner, 2004).

DISCUSSIONS

1: TECHNICAL AND ADMINISTRATIVE PROBLEMS

Outside of the problem of numerical tolerance that was addressed in the *Weaknesses of the System* section of the *Evaluations*, the LON-CAPA homework sets seemed to operate quite smoothly. This was not the case for the quizzes that were administered through the LON-CAPA system.

There were two problems that occurred with the trigonometry online quiz (Appendix G). The first problem that some students encountered was the result of the students entering into a course that was no longer valid. Over the course of the summer, the LON-CAPA support staff at Michigan State University had removed the server that had been installed in the Grand Ledge school district. As such, I thought that the course information would be placed in the Michigan State University domain (msu), as that was where the server was physically located and where the course information was stored. However, the LON-CAPA staff had kept the Grand Ledge Public Schools (glps) domain active and as such, all Grand Ledge courses were stored under that domain. Unfortunately, I had already started the students in the msu domain.

By the end of the first unit, prior to this study, the problem had been corrected and the course and student information had been moved to the glps domain. However, some students continued to enter the incorrect domain when logging into the system. This problem became quite evident during the quiz, as I had not yet entered the quiz into the system before the course information had been moved into the glps domain. Those students who logged into the msu domain found that there was no quiz available to them. This problem was easily rectified by having the student exit out of the system and then log back into it using the correct domain (glps).

The second problem was a bug that occurred within the system. For a reason that I was unable to determine at the time, some students encountered a very odd problem. The system would display a problem that was not theirs. The students would then complete the problem and submit it. The computer would compare their answer against the actual correct answer for the problem that they should have seen and inform the students that their answer was incorrect. At that point, the system would display their actual problem and the students would be able to continue on from there. The root of the problem lies with the caching function of the school district's server. If the problem page was stored in the server's cache then it may have called up a previous problem instead of bringing up the actual problem, as the purpose of the cache is store recently viewed pages on a computer's hard drive so that they can be recalled faster than if they had to be downloaded from the Internet each time. Once the student entered an incorrect answer, it would access the actual problem as now the page had changed to indicate that they had entered an incorrect answer and the cached page was no longer valid.

What concerned the students was the fact that for this quiz, I had reduced the number of attempts that the system would accept down from the twenty attempts that I allow for the homework problems down to three attempts for the quiz. My reasoning for this was that with twenty attempts the students would be able to simply take the sine, cosine, or tangent of everything they saw in the problem until they hit upon the correct answer. As such, many students were concerned that they had used one of their three answers on a problem that was not correctly displayed.

My solution to this was to accept one written answer from the students for whom this problem had occurred. This way, they still had three attempts at the correct problem. Since I have access to all of the problems and solutions, I would be able to manually grade the solutions and they would not be penalized for a shortcoming in the system. Of all of the students who approached me with this problem, only one student handed in a written copy of the work for me to grade. The rest of the students were able to determine the correct answers with their remaining two attempts. Since there is instant feedback in regards to whether their answer is right or wrong, the students were able to walk out, certain that even though they had lost an attempt, they still were not penalized, as they knew that the problems had been completed correctly. All of these technical problems were minimized as the day progressed, as I was able to make preemptive announcements concerning these issues at the beginning of the period for the third and sixth period courses.

With the LON-CAPA based projectile motion quiz (Appendix H), problems arose when the students tried to access the quiz set. Even though they had no difficulties accessing the LON-CAPA system, they were not able to gain access to the quiz set. I found it even more frustrating that I was able to access the quiz set. The rest of the class period was spent trying to get students into the quiz without any success.

Over the weekend I reviewed the quiz problems from within the construction space. After reviewing the published pages I found that the problem was in the level of access that I had granted for the quiz set. When I developed the problems and resource materials for the quiz, I had published them in such a way as to only give access to myself. Publishing them at this level of accessibility allowed me to view the problems as they would actually appear and make changes to the problems. At the same time the problems were inaccessible to the rest of the system users, students and instructors both. This would prevent any other instructors from discovering these problems within the resource space and implementing them into their online courses before I was satisfied that the problems were complete and error free. Since I saw no indication from inside the course that they are only accessible to me, I had forgotten to change the level of access to grant all users access to the problems. This explains why I was still able to pull up the quiz set without any problems while none of the students were able to do so.

An additional problem arose due the way in which I had coded the problems. There were three questions that I wanted to tie into the QuickTime movie. The only way that I had found to include all three pieces into the movie and still have the movie accessible to the students while working on all three of the problems was to code the three problems as if they were multiple responses to a single problem. The issue with this is that the system would grade all three responses of the problem at once and only indicate to the user that the problem was correct if all three parts of the problem were correct. If any of the three responses were incorrect, then the system would simply indicate to the student that the problem was wrong. It would not show which of the responses was wrong. This was a considerable source of anxiety for the students as once again, I had reduced the number of tries and it was only being given during the class period, time was a factor. During the period I announced to the class that they would be allowed to turn in one written copy of the work if they did not get the quiz set correct within the allotted tries. This was once again somewhat counterproductive as one of the advantages of the LON-CAPA system is that the system grades the sets for the instructor and I was yet again taking home a stack of papers to grade.

The results for LON-CAPA based projectile motion quiz were not as promising as those of the previous online quiz over trigonometry functions. As described earlier, the quiz required the students to take data with a stopwatch from a QuickTime movie embedded into the quiz problem set. Many of the students struggled to get accurate data with the stopwatch. I had increased the tolerance that the system would accept for a correct answer from the typical one percent that I usually used to ten percent in order to make up for any discrepancies in stopwatch use. As I tested the quiz I found that I was never more that ten percent away from the actual time of 2.25 seconds for the ball as it fell to the ground. Many students had difficulties seeing the screen and were not able to start at the appropriate time or stopped the watch too early. In either case, they consistently measured times of only 2.00 seconds for the flight of the ball and as such, their data took them outside of the range of the system was programmed to accept.

Although the results for the LON-CAPA based quiz seemed less of an indicator of student performance than the lab-based quiz, it should be noted that the lab-based quiz was one that I have administered for each of the seven years that I have taught physics. I have had the opportunity to anticipate many of the problems that occur when administering this quiz. The LON-CAPA quiz was administered for the first time and many problems occurred that I had not anticipated. I feel these problems provided distractions that kept the students from focusing all of their attention strictly on the objectives that were being tested at the moment.

2: INSTRUCTIONAL ISSUES AND ONLINE LECTURE NOTES

With the cart of laptop computers located in my classroom, students had access to the Internet and the class materials located on the LON-CAPA system. I found this level of access to be sometimes troublesome throughout the course of the study. Since textbook problems that I gave the students to do were not graded, they were often ignored. These problems were identical for everyone, enabling me to work through the problems with the students and have everyone follow along. When working on the section of the vector addition unit that dealt specifically with vector addition, perhaps the most important section of the unit, I found that students were more concerned with the problems that are going to be counted in the grade book than those problems that were given to them for their own enrichment. Those students who did elect to spend the class period working on the handwritten vector addition problem set cited that they believed me that mastering these problems would benefit them. Some of them even said that by mastering this skill first, completing the LON-CAPA homework set would be much easier to do.

This problem persisted throughout the unit. When I asked if the students had any difficulties with the enrichment problems concerning inclined surfaces, most of the students admitted that they had not completed the assignment. When I queried the class why they had not completed the assignment, most of them cited that they had spent the class period working on their LON-CAPA set instead of the three enrichment problems that I had given them. The students immediately gravitated towards those problems that were to be graded and allowed the problems that were given to them in order to strengthen their abilities in the material at hand to fall to the wayside.

Eventually, I had to deal with this by taking choices away from the students when I felt that one option best served them. As they began to review for the vector addition test, I did not give them the choice to work on the review or the LON-CAPA set. The computers remained locked up in the cabinet and the students had only the review problems to work on. While working on the "fly ball" project in the projectile motion unit, several students opted to spend their time working on their LON-CAPA homework sets, rather than work on their projects. Since it was quite possible that they may have had the projects completed by that time, I gave then the option to work on either, but I made it clear that there was a definite hierarchy in terms of whom I would help in the class.

A similar problem occurred with the use of the online lecture notes. My intention was that they be made available to students wherever they might be, I found that the students' reliance on these notes bordered on abuse and I believe at times it was counterproductive: they were not taking their own notes. I had stressed to the students the importance of keeping written lecture notes to help reinforce what was being discussed during the class period. In talking with the students, I found that the students who had the most positive things to say about the lecture notes were the students who used the online lecture notes as a basis for the notes that they took in class. This is similar to Kozma's findings where students participating in online coursework had positive attitudes towards the class and acquire new knowledge, but did not necessarily improve their study habits (2003).

I have noticed that the implementation of the LON-CAPA system has significantly changed how I present material in my class. There are obvious advantages to having all of the lecture notes available to the instructor at all times. Before administering the LON-CAPA based trigonometric functions quiz I had to go over information that was not covered in the previous day's lecture. I found that a great benefit to having the notes online is that when I am unable to complete all of a given section in one day, it is easy to bring up the notes and backtrack a bit in order to bring the students up to pace on the material that was covered the previous. Since they are the same notes that were seen the day before, the students find the material to be familiar and the lesson seems much more continuous, even though it has been broken up over the course of two lecture periods.

My approach to the course material has changed as well. With the system grading the students' assignments, I found that I was less concerned with the actual answers to problems and instead, I focused on sound reasoning and procedures more than I had done in the past. As observed by other LON-CAPA users, the system had now taken over the role of evaluator (Morrisey, Kashy, Tsai 1995) and the typical student – content interaction of one-way information delivery has been supplemented with roles of reinforcement and motivator. This freed me from answering questions of "What's the answer?" and allowed me to focus on questions such as, "Why are these relationships so?" and "How do these concepts tie to each other?" In turn, this also shifted the students from the role of passive learners to that of active learners, which has been linked to creating more student-centered classes (Seng & Al-Hawamdeh, 2001; Lederman & Niess, 2000).

When discussing the procedure for adding vectors together, many of the students who had already completed a FST, prerequisite math course, were quick to observe that mathematically, these vectors could be added together in a single step using either the law of sines or the law of cosines. I had to stress to those students that I would insist that they stick to simply using the trigonometry functions that we had already discussed. The reason for this was that although these techniques are a time saver for students, in the coming units, they would need to be adept at breaking vectors into their components. Since I was able present this as a way of helping the students, most of them were able to see this my way and were more than happy to cooperate.

3: COURSE MANAGEMENT

Even though it was not a primary goal in the implementation of the LON-CAPA system, after having read the literature (Morrissey, Kashy, & Tsai, 1995), I had hoped that I would save time that was normally spent grading student work and providing feedback. However, I do not believe that the implementation of the LON-CAPA system in my class has saved me any time overall. However, the time that I spend on my class is far better spent since its implementation. The hour or so each night that I normally spent grading homework and preparing lecture notes for the next day was now spent online, conversing with students and helping them. I tried to maintain a system where I would only answer questions about a particular problem once. After that point, I would instruct those that had learned how to successfully complete the problem to help others who had questions on it. This was not always effective, but it did allow me to address a greater number of problems. Following this policy helped to promote positive interaction between the students through the LON-CAPA system.

Even though no one had identical problems, having one set assigned to the teacher was also an advantage as it allowed me to work through my problems with the class as examples of how they could solve theirs. This strategy worked particularly well on long and difficult problems such as the "volleyball" problem in the projectile motion homework set (Appendix B). In addition to the level of difficulty involved in this problem, there was a fair amount of anxiety on the students' part as there were six parts to this question. After going through the problem with a few students online, I decided that it would be far more efficient to announce to the group that I would go over an example problem like this one the next day in class. This worked out well as it allowed the students to relax a bit on that problem and it freed me up to answer questions about a greater variety of problems that night.

4: CONCLUSIONS AND FUTURE GOALS

Technology has now become a tool to be used by teachers to improve their classes with improved content and ramped up delivery of that content through improved channels of communication. In reference to the dilemma posed by the administrator at the beginning of this paper, is this an implementation of technology simply for the sake of implementing technology into the classroom? In terms of the numerical data in this study, there are no conclusive results to report. Although subjectively it seems that the trends support the use of LON-CAPA to master course objectives, statistically speaking, the differences were not significant. The students who performed well on the online homework sets had greater success in learning the course objectives than those who did not perform as well on the homework sets. But the differences between those who did or did not learn the objectives were not significant given the size of the sample of students. Of those students who did not successfully complete elements within the online homework set, those who made the most attempts did perform better on the post-test assessment. But once again, the difference was not significant. The information provided on the surveys indicated that the students recognized the strengths of the LON-CAPA system, specifically the availability of materials both at school and at home, and the ability to communicate effectively with everyone enrolled in the course as well as with the instructor.

However, this system has addressed the needs of the students when they are not in the classroom. By incorporating the class lecture notes into the system, the material is both important and relevant. The students are also given greater autonomy and responsibility for their own learning with the format of the homework sets. With the communication features, the students maintain a voice in the class. And the teacher feedback provides the teacher with a means of continually adapting the course to meet the needs of the student. These are all features that have been identified as crucial to the success of online course management (Simonson & Schlosser, 2004)

The teacher needs to address what he or she wishes to gain by implementing such a tool in their class and then develop strategies for adapting the system to meet those goals. My goals were to increase the availability of information and resources to the students, especially those who were absent from the class. In order to meet these goals, I first created a framework in the system that was consistent with what the students see in class. The units were divided into the same content. The homework was divided into the .PDF files that they could download in case they had missed a handout and the online homework set that would be graded at the end of the unit. Since this was the same for each unit, the students knew what the expectations of them were and could plan appropriately.

Also, I believe that the communication features, while invaluable, must be promoted within the classroom in order for them to be effective. Furthermore, they need to be shown the advantages of using these tools. Once students realize that they are no longer on an island when they are in the system, they are much more apt to make use of the communication tools.

In the coming years, I intend to further implement the LON-CAPA system into my physics class. Although there are a few flaws that need to be edited out of the online lecture notes, once these are complete, the notes will be published system wide so that they will be available to all of the system teachers. Based on feedback from other high school teachers at the most recent LON-CAPA conference (2005), there is a fairly high demand for such material. I would also like to further incorporate the online homework assignments into the content of the online lecture notes. One of the most frequently asked questions by the students was what problems should they be able to solve at the end of each class. Using a feature called sequencing, resource materials, such as the online lecture notes can be tied directly to relevant homework problems. I believe that this would serve two purposes as it would not only allow students to see which problems are within their abilities at any given point in a unit, but it would also help to motivate the students to work on problems earlier in the unit. As it is right now, I believe that many students wait until just before they are due to work on the homework sets, since that is when they know that they have covered all the material in class.

The last possibility that I would like to investigate is the implementation of such a system with one of the current web-based district management software packages, such as Apple's PowerSchool. PowerSchool already incorporates features that allow teachers to link assignments to the parent and student viewer sides of the program. It would be ideal if students were able to access resource materials and their particular problem sets from within this program so they could see how the completion of each assignment directly affects their grade within a class. Such access to information would give the student an unprecedented level of control over his or her personal outcomes within a class and would help to create a model of education that centered about the student.

APPENDICES

APPENDIX A

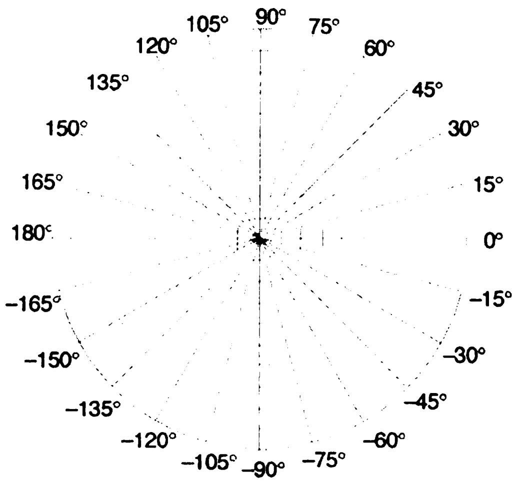
LON-CAPA HOMEWORK PROBLEMS

VECTOR ADDITION

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Vectors and Scalars

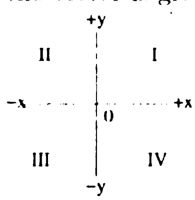
A flea pulls on a puck with force 8 μN at an angle of 90°. Another flea pulls on the puck with force 1 μN at an angle of -60°. (See diagram for angle scale.) Draw vectors on the diagram to scale representing the forces. Carefully add the vectors tip-to-tail. (Use a ruler.) (a) What is the magnitude of the net force on the puck? (b) At what angle is the net force? (Answer in ° using the angle scale provided.)



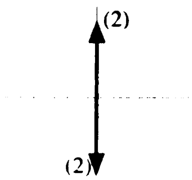
Tries 0/20

Due date: Fri 12 Nov 2004 11:59:59 PM EST

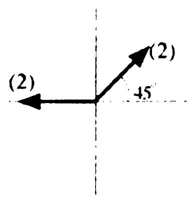
Each of the following situations shows two or more force vectors. You are to determine the direction of the **sum** of the forces. If the direction is exactly along one of the axes, chose that **axis** (+x,-x,+y,-y). Otherwise select the quadrant (I,II,III, or IV) or zero if the net force is 0. The length of the vector is given in parentheses.



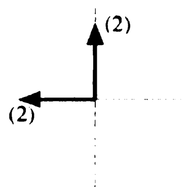
Choices: **+x, -x, +y, -y, I, II, III, IV, zero.**



A.



B.

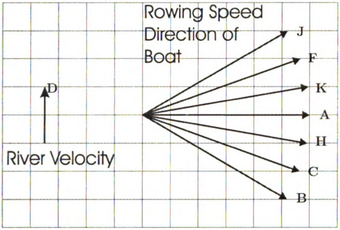


C.

You are correct. Your receipt is 160-2676

Due date: Fri 12 Nov 2004 11:59:59 PM EST

A river is to be crossed by a boy using a row boat.



Assume that the water has uniform velocity, represented above by the vector labeled D. The rowing speed of the boy and a set of possible orientation of his boat are also shown. Select the direction (i.e., J, or C, or ...) in order to cross the river in the shortest time. (Notice that the number of tries is reduced.)

You are correct. Your receipt is 160-2934

For which rowing orientation will the boy land on the opposite shore directly across from his starting position, neither upstream or downstream. (Notice that the number of tries is reduced.)

You are correct. Your receipt is 160-3520

Select an answer for each .... below.

Choices. **Greater than**, **Less than**, **Equal to**.

A. For an observer on shore, the speed of the boat for H is .... for A.
B. Time to row across for J is .... for B.
C. Time to row across for F is .... for J.
D. The distance traveled in crossing for K is .... for H.
E. Time to row across for C is .... for B.

You are correct. Your receipt is 160-3668

Due date: Fri 12 Nov 2004 11:59:59 PM EST

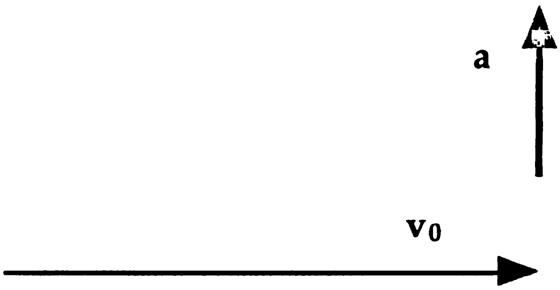
A canoeist can paddle at 4.97 m/s in still water. He starts to paddle across a river, but is pushed downstream by a current of 11.68 m/s. What is the resultant speed of the canoe?

You are correct. Your receipt is 160-3057

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Vector Addition/Substraction

An object having velocity $\vec{v}_o$ undergoes an acceleration $\vec{a}$ as depicted in the figure. The acceleration lasts for a definite nonzero period of time.

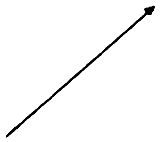


Which of the following vectors could represent the velocity vector after acceleration? Determine for each of the following graphs whether it is correct or incorrect.

Choices: **Correct**, **Incorrect**.

A. 

B. 

C. 

D.

E. It is impossible to answer because the duration of the acceleration is not specified.

You are correct. Your receipt is 160-1509

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Harbor Problem

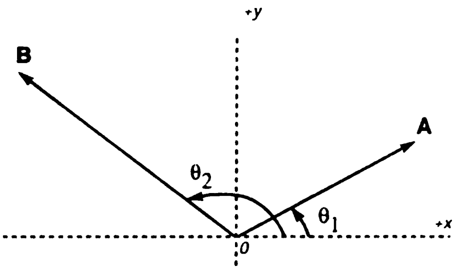
At the entrance channel of a harbor, the tidal current has a velocity of 5.14 km/hr in a direction 15.5° south of east. Suppose a ship caught in this current has a speed of 18.4 km/hr relative to the water. If the helmsman keeps the bow of the ship aimed north, what will be the speed of the ship relative to the ground?

You are correct. Your receipt is 160-1503

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Data:

$\theta_1 = 37.3$	$\theta_2 = 145.6$
A = 4.3 cm	**B** = 7.2 cm



With the diagram and the above data answer these questions:
What is the x component of vector A?

You are correct. Your receipt is 160-3124
What is the y component of vector A?

You are correct. Your receipt is 160-2459
What is the x component of vector B?

You are correct. Your receipt is 160-3045
What is the y component of vector B?

You are correct. Your receipt is 160-3205
What is the magnitude of vector (A + B)?

You are correct. Your receipt is 160-2540

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Raindrops

On a rainy day, raindrops fall with a vertical velocity of 10.9 m/s. If a car drives through the rain at 71.0 km/hr, what is the magnitude of the velocity of the raindrops relative to the car?

You are correct. Your receipt is 160-1915

At what angle are the raindrops falling relative to the car? Assume the direction the car is headed is 0° and down is 90°.

You are correct. Your receipt is 160-2501

Due date: Fri 12 Nov 2004 11:59:59 PM EST

A group of kids is on a hike. They hike 17.4 km east, then turn and walk 15.5 km north.

A. What is there distance from their original position? [ ]

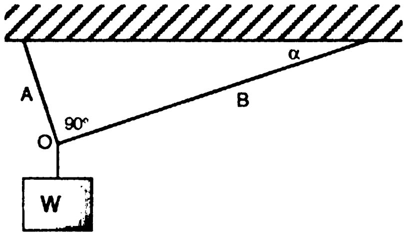
You are correct. Your receipt is 160-3481
B. What is the angle of direction to their position? [ ]

You are correct. Your receipt is 160-4067

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Suspension Wires

An object at rest is suspended from two strings (A and B) as shown in the diagram, with A shorter than B. The object pulls on the point O with a force of 20 N. Each of the strings also exerts a force on the Point O. The angle between the strings at O is 90°.



Which of the statements below are true/false?

Choices: **True**, **False**.

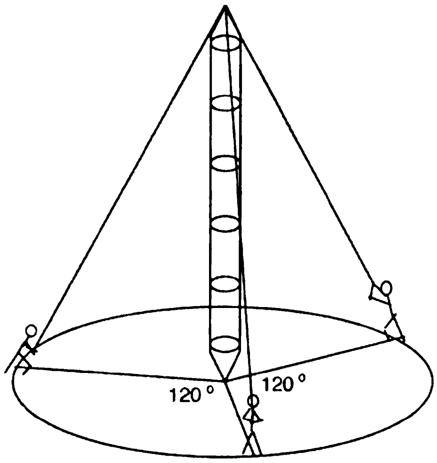
A. The force exerted by A on point O points downward and to the right.
B. The vector sum of the forces exerted by A and B points straight up.
C. The magnitude of the vector sum of the forces exerted by A and B is less than 20 N.
D. The magnitude of the force exerted by B on point O must be smaller than that of A.
E. The magnitude of the force exerted by B may be larger than 20 N.

You are correct. Your receipt is 160-1811

Due date: Fri 12 Nov 2004 11:59:59 PM EST

Mast Problem

The figure below shows three (stick) people pulling down via ropes, each with 206 N, on the top of a mast 20.0 m tall. If they stand at equal distances of 18.1 m from the base of the mast and at equal distances from each other, i.e. 120° apart, what is the net force that they exert on the mast?



You are correct. Your receipt is 160-1807

APPENDIX B

LON-CAPA HOMEWORK PROBLEMS

PROJECTILE MOTION

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Horizontal Launch 1 (Helicopter)

A helicopter is flying in a straight line over a level field at a constant speed of 18.2 m/s and at a constant altitude of 17 m. A package is ejected horizontally from the helicopter with an initial speed of 13.8 m/s relative to the helicopter, and a direction opposite to the helicopter's motion. Find the initial speed of the package relative to the ground.

Tries 0/20

What is the horizontal distance between the helicopter and the package at the instant that the package strikes the ground?

Tries 0/20

What angle between 0° and 90° does the velocity vector of the package make with the ground at the instant before impact, as seen from the ground?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Horizontal Launch 2 (Stone)
A stone thrown horizontally from a height of 10.0 m hits the ground at a distance of 19.5 m. Calculate the initial speed of the ball.

Tries 0/20

Calculate the speed of the ball as it hits the ground.

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Simple Projectile

A projectile is fired at 27.5° above the horizontal. Its initial speed is equal to 102.5 m/s. Assume that the free-fall acceleration is constant throughout and that the effects of the air can be ignored. What is the maximum height reached by the projectile?

Tries 0/20

At what time after being fired does the projectile reach this maximum height?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Simple Projectile

A small steel ball bearing with a mass of 13 g is on a short compressed spring. When aimed vertically and suddenly released, the spring sends the bearing to a height of 1.33 m. Calculate the horizontal distance the ball will travel if the same spring is aimed 39° from the horizontal.

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Simple Projectile (Golfball)

A golf ball hit with a 7-iron soars into the air at 38.0° with a speed of 55.5 m/s. Overlooking the effect of the atmosphere on the ball, determine the ball's range.

Tries 0/20

Determine when the ball will strike the ground.

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Simple Projectile (Salmon)

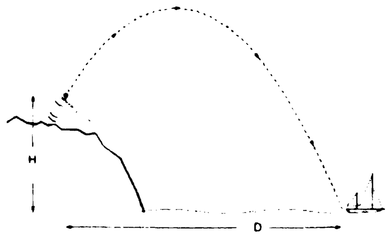
Salmon, swimming up the Fraser river to their spawning grounds, leap over all sorts of obstacles. The unofficial salmon-altitude record is an amazing 3.36 m jump. Assuming the fish took off at 45.0°, what was its speed on emerging from the water? Ignore friction.

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Catapult

A catapult on a cliff launches a large round rock towards a ship on the ocean below. The rock leaves the catapult from a height H = 34.0 m above sea level, directed at an angle θ = 46.5° above the horizontal, and with a speed v = 27.5 m/s. Assuming that air friction can be neglected, calculate the horizontal distance D traveled by the projectile.

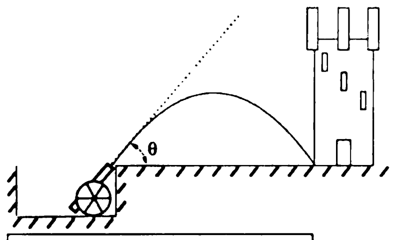


Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Medieval Castle

Assume you are a Medieval knight attacking a castle with a cannon. The ball leaves the cannon with a speed of 34.9 m/s. The barrel's angle with respect to the ground is 39.1°, and you make a perfect hit on the tyrant's chamber which is at the same level as the cannon's muzzle. What is the time of flight of the cannon ball?



Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions

The launching speed of a certain projectile is 6.2 times the speed it has at its maximum height. Calculate the elevation angle at launching.

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions

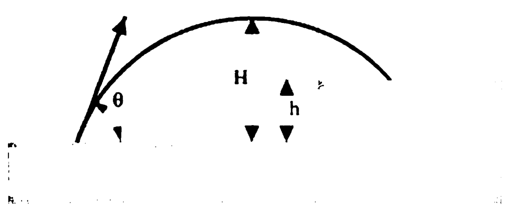
A ball is thrown horizontally from a height of 17.79 m and hits the ground with a speed that is 5.0 times its initial speed. What was the initial speed?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions (Cliff)

A stone is aimed at a cliff of height h with an initial speed of 90 m/s directed 30° above the horizontal, as shown in the Figure below. The stone strikes at A, 7.80 s after launching. What is the height of the cliff?



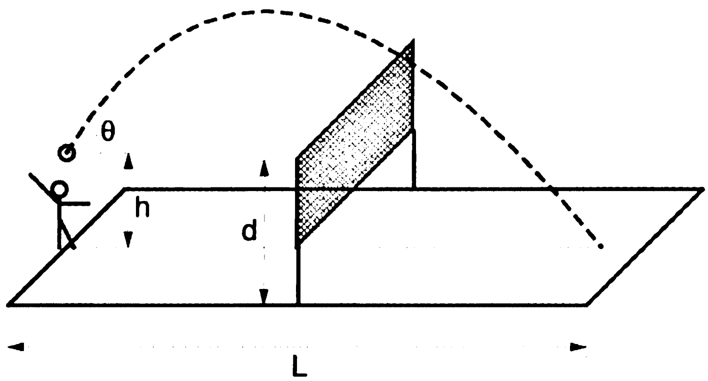
Tries 0/20

What is the maximum height H reached above the ground?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions (Volleyball)
A regulation volleyball court is L = 18.0 m long and a regulation volleyball net is d = 2.43 m high. A volleyball player strikes the ball a height h = 1.53 m directly above the back line, and the ball's initial velocity makes an angle θ = 40° with respect to the ground (see the figure). At what initial speed must the ball be hit so that it just barely makes it over the net? (Assume the volleyball is hit so that its path is parallel to the side-line as seen from an observer directly above the court, and that the volleyball is a point object.)



You are correct. Your receipt is 160-2261
What is the maximum height above the court reached by the ball in this case?

You are correct. Your receipt is 160-2847
At what initial speed must the ball be hit so that it lands directly on the opponent's back line?

You are correct. Your receipt is 160-2995
What is the maximum height reached by the ball in this case?

You are correct. Your receipt is 160-2330
In volleyball, it is often advantageous to serve the ball as hard as possible. If you want the ball to land in the opponent's court, however, there is an upper limit on the initial ball speed for a given contact point. At this maximum speed, the ball just barely makes it over the net and then just barely lands in bounds on the back line of the opponent's court. For the contact point given in the previous problems, what is this maximum initial speed?

You are correct. Your receipt is 160-2916
If you hit the ball at this maximum speed, at what angle should you strike it in order to make sure the ball lands in bounds?

You are correct. Your receipt is 160-2263

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions (Horse Jump)

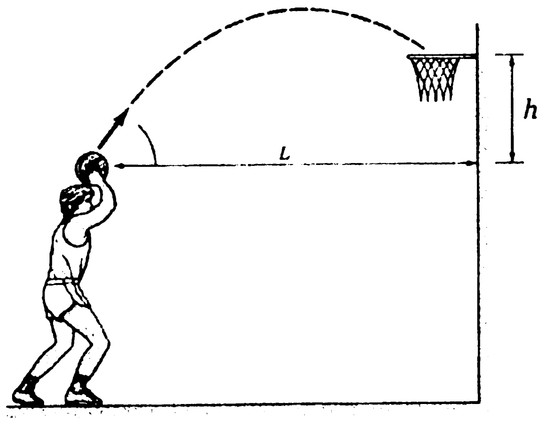
During a famous jump in Richmond (Virginia) in 1903 the horse Heatherbloom jumped over an obstacle 3.1 m high while covering a horizontal distance of 8.3 m. At what angle with respect to the horizontal did the horse leave the ground?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions (Basketball)

A basketball player throws the ball at a 35° angle above the horizontal to a hoop which is located a horizontal distance L = 2.2 m from the point of release and at a height h = 0.3 m above it. What is the required speed if the basketball is to reach the hoop?



Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

2D and 3D Motions (Baseball)

The center of a baseball of diameter 9.00 cm is 1.270 m vertically above the plate when it is hit. The blast sends it off at an angle of 30.0° above the horizontal with an unknown initial speed. The outfield fence is 101.0 m away and 11.20 m tall: the ball just clears it. Ignoring aerodynamic effects, what was the initial speed of the baseball?

Tries 0/20

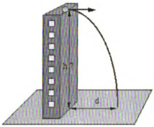
Due date: Fri 03 Dec 2004 11:59:59 PM EST

The soccer goal is 26.31 m in front of a soccer player. She kicks the ball giving it a speed of 18.78 m/s at an angle of 26.47 degrees from the horizontal. If the goalie is standing exactly in front of the net, find the speed of the ball just as it reaches the goalie. [ ]

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Height

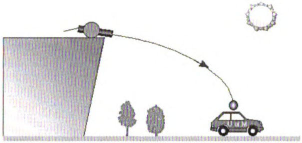


A snowball is launched horizontally from the top of a building at v = 10 m/s. If it lands d = 41.5 meters from the bottom, how high (in m) was the building?

Tries 0/20

Due date: Fri 03 Dec 2004 11:59:59 PM EST

Speed 2



A cannon is fired from a cliff 100 m high downward at an angle of 32^o with respect to the horizontal. If the muzzle velocity is 33 m/s, what is its speed (in m/s) when it hits the ground?

Tries 0/20

APPENDIX C

VECTOR ADDITION UNIT OBJECTIVES

Objective 1:

Vectors represent two quantities. In this course, those two quantities are magnitude and direction. Graphically, vectors are represented by rays, where the length of the ray is scaled to represent the magnitude and the arrowhead indicates the direction.

Objective 2:

Scalars only represent one quantity.

Objective 3:

Trigonometry is used to add vectors together so that there directions are taken into account.

Objective 4:

Vectors follow the commutative property and as such it does not matter in what order they are added

Objective 5;

All vector measurements must be made with direction in mind. As such, vectors that are in the same direction affect have an effect on each other.

Objective 6:

Quantities that are orthogonal to each other are independent of each other.

Objective 7:

Vectors that lie in the same direction can be added algebraically.

Objective 8:

When adding vectors, components acting in the same direction are added algebraically.

APPENDIX D

PROJECTILE MOTION UNIT OBJECTIVES

Objective 1:

Motion in the vertical direction is independent of motion in the horizontal direction.

Objective 2:

Acceleration due to gravity only affects the vertical component of a projectile's motion.

Objective 3:

Horizontal motion is unaffected by gravity. If resistive forces are not taken into account, the horizontal component of projectile's velocity remains constant.

Objective 4:

Overall velocity, which is a vector consisting of both magnitude and direction, is the resultant of the addition of the vertical and horizontal components of the object's velocity at that moment.

Objective 5:

If an object lands at the same height from which it was launched, then the trip displays horizontal symmetry about a vertical line that passes through the highest point in the objects flight.

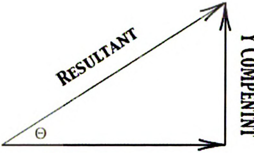
APPENDIX E

SAMPLE ONLINE LECTURE NOTES

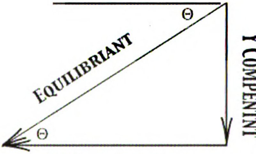
Unit Notes 2-5

Equilibriant

Often we will deal with systems that are in equilibrium, which is to say that there is no net dynamic in the system. In order for this to be true, all of the involved must add up to zero. In terms of the previous section, this only adds one step to the process, consider it to be Step 3b.



After finding the resultant, the equilibriant can be found by simply reversing the direction of the resulant. This is perhaps easiest to figure by using the components of the resultant. The components of the equilibriant have the same magnitude as those of the resultant, but their signs are reversed.



It is also worth noting here, that in a case of an equilibrium, where all the vectors add up to zero, the same must be true of all of their components, which is to say that the net change in both the x and y directions must be zero.

APPENDIX F

PRE-TEST AND POST-TEST ASSESSMENTS

Vectors (Pretest)

1. Define what a vector is....
What is represented by a vector? How does it differ from a scalar quantity? How are vectors represented numerically? How are they represented graphically?

2. Given the following: Vector A = 12.0 km due North, and Vector B = 18.0 km due East, answer the following: What is A + B? Is it the same as B + A? (Why or why not?) Why is you answer not 30.0 km?

3. A man attempts to cross a river in a rowboat. The man is capable of rowing the boat at 3.5 m/s. The current is travelling due south at 2.6 m/s. If the man rows due west, how long will it take him to cross the river, given that it is 75 meters wide at the point where he is crossing?

4. How far downstream will the man in the previous question end up when he gets to the other side?

5. Relative to the banks of the river, what is the fastest that the man can travel? What is the slowest that he can travel, assuming that he is always rowing at his top speed.

6. What direction should he point the boat in order to travel directly across the river?

Vectors

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Vectors

1. Define what a vector is....
What is represented by a vector? How does it differ from a scalar quantity? How are vectors represented numerically? How are they represented graphically?

Vector are items that describe two quantities. In this class vectors have both magnitude and direction. Scalars have only one property.

Numerically, it takes two quantities to describe a vector, one for the magnitude and one for the direction. Graphically they are described using rays, where the length of the ray corresponds to the magnitude and the arrow indicates the direction.

2. Given the following: Vector A = 12.0 km due North, and Vector B = 18.0 km due West, answer the following: What is A + B? Is it the same as B + A? (Why or why not?) Why is you answer not 30.0 km?

21.6 km, 33.7 degrees North of West.

Yes this is the same as B +A, because vectors are commutative.

The answer is not 30 km (12 km + 18 km) because the two vectors do not lie in the same direction.

7. A man attempts to cross a river in a rowboat. The man is capable of rowing the boat at 3.5 m/s. The current is travelling due south at 2.6 m/s. If the man rows due west, how long will it take him to cross the river, given that it is 75 meters wide at the point where he is crossing?

21 seconds

8. How far downstream will the man in the previous question end up when he gets to the other side?

56 meters

9. Relative to the banks of the river, what is the fastest that the man can travel? What is the slowest that he can travel, assuming that he is always rowing at his top speed.

Fastest: 6.1 m/s, South

Slowest: .9 m/s, North

10. What direction should he point the boat in order to travel directly across the river?

48 degrees North of West

Projectile Motion (Pretest)

1. Given what you've learned in the previous unit, what do you think the advantage would be of breaking up an object's motion into horizontal and vertical components?

2. How does the acceleration due to gravity affect the motion of a projectile?

3. If a ball rolls off of a 1.3 meter high counter with a velocity of 4.5 m/s, how far away from the base of the counter will the ball land?

4. What will the ball's velocity be as it strikes the floor?

5. Mr. Hackborn strikes a golfball with a 7-iron, sending it up into the air at a 60 degree angle with the horizontal. The ball land 165 meters away on the green which is at the same elevation as the point from which the ball was hit. What was the ball's velocity as it left the club?

6. A child is lauched out of a tube in a waterpark ride. The child leaves the tube at 8.6 m/s, at an angle of 27 degrees above the horizontal. He lands in the pool, 15.8 meters beyond the point where he was launched. How high above the pool was he launched?

7. What was his velocity as he struck the pool?

Projectile Motion

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Projectile Motion (Pretest)

1. Given what you've learned in the previous unit, what do you think the advantage would be of breaking up an object's motion into horizontal and vertical components?

Breaking up the motion into it's components allows one to isolate the horizontal and vertical motions, which are independent of each other.

2. How does the acceleration due to gravity affect the motion of a projectile?

Gravity causes the object to accelerate in the vertical direction only. This causes the vertical componenent of an object's velocity to become more negative.

8. If a ball rolls off of a 1.3 meter high counter with a velocity of 4.5 m/s, how far away from the base of the counter will the ball land?

   2.3 meters away from the base

9. What will the ball's velocity be as it strikes the floor?

   6.8 m/s

   48 degrees below the horizontal

10. Mr. Hackborn strikes a golfball with a 7-iron, sending it up into the air at a 60 degree angle with the horizontal. The ball lands 165 meters away on the green which is at the same elevation as the point from which the ball was hit. What was the ball's velocity as it left the club?

43 m/s

11. A child is lauched out of a tube in a waterpark ride. The child leaves the tube at 8.6 m/s, at an angle of 27 degrees above the horizontal. He lands in the pool, 15.8 meters beyond the point where he was launched. How high above the pool was he launched?

12.6 meters

12. What was his velocity as he struck the pool?

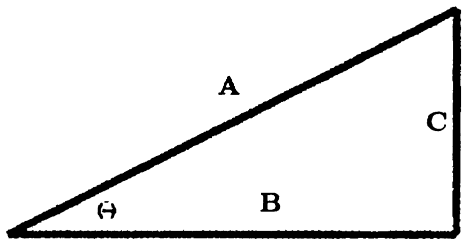
18 m/s

65 degrees below the horizontal

APPENDIX G

LON-CAPA TRIGONOMETRY QUIZ

Due date: Sat 20 May 2006 12:00:00 AM EDT



Match the following:

Choices: **A**, **B**, **C**.

A. Opposite

B. Hypotenuse

C. Adjacent

Tries 0/3

Given a triangle whose hypentuse measures 4.1 meters, and has an angle of 63.03 degrees, what is the length of the side adjacent to the angle?

What is the length of the side opposite the 63.03 degree angle?

Tries 0/3

Given a right triangle with a leg whose length is 9.7 meters, adjacent to a 63.03 degree angle, what is the length of the hypotenuse?

What is the length of the side opposite the 63.03 degree angle?

Tries 0/3

Given a triangle with a leg of length 7.8 meters, located opposite a 17.19 degree angle, what is the length of the hypotenuse?

What is the length of the leg adjacent to the 17.19 degree angle?

Tries 0/3

APPENDIX H

LON-CAPA PROJECTILE MOTION QUIZ

Due date: Sun 05 Dec 2004 02:45:00 PM EST

Use a stopwatch to record the time that the ball was in the air. (Listen for it to hit the ground.)

How fast was the ball traveling when it left the parking deck? (Assume that the ball was traveling horizontally.)

What is the height of the parking garage?

The ball rolled down a ramp that makes a 49^o angle with the horizontal before leveling off and rolling off the parking garage. How long is the ramp?

Tries 0/10

Watch the film below and answer the following questions.

Choices: **True**, **False**.

A. The initial velocity of the ball in the video is more than that of the ball in the previous video.

B. Neglecting air resistance, if the ball was lighter, it would have traveled farther.

C. If the ramp was half as high, the ball would have landed half as far away.

D. If a second ball had been dropped from the garage at the same time, the second ball would have hit the ground after the ball that was launched horizontally.

Tries 0/10

APPENDIX I

LAB-BASED PROJECTILE MOTION QUIZ

Projectile Motion Lab/Quiz

1. As a group, move to an unused workstation in the lab area.

2. Confirm that all lab equipment is there. It should include the following…
   1 marble
   1 marble launcher
   1 meter stick
   1 stopwatch

3. You have 25 minutes to determine as much information as you can about the flight of the ball from the launcher. Record your information as well as your procedure for finding it on a separate sheet.

4. After 25 minutes, I will be around to collect your marble from your group. I will also at this time give you a paper target on an elevated surface. You must place the target as such that when the marble is once again released from the launcher, it will strike the target on the elevated surface.

5. When you group is ready to launch, call me over and I will give you back your marble and place a piece of carbon paper over the target to record where the marble hits. You will be given only one launch.

APPENDIX J

STUDENT SURVEY

Student Survey

How often do you access the LON-CAPA system?

Daily		Weekly		Monthly
1	2	3	4	5

Please check all the sections that you frequently view:

______ Lecture Notes

______ Daily Assignments (pdf's in Lecture Notes)

______ Homework Assignments

______ Calendar

______ Labs

______ Discussion Boards

______ Web Resources

How useful do you find the online lecture notes to be?

Very		Somewhat		Not At All
1	2	3	4	5

If you regularly access the online lecture notes, how do you use them?

Supplement to notes taken in class	1
Reference aid to online homework problems	2
In lieu of taking notes in class	3

Do you print off hard copies of the online lecture notes?

How effective do you find each of the online communication methods to be?

Email:	Very	Somewhat	Not At All
Chat Room:	Very	Somewhat	Not At All
General Discussion Board:	Very	Somewhat	Not At All
Homework Discussion:	Very	Somewhat	Not At All
Lecture Note Discussion:	Very	Somewhat	Not At All

What do you feel are the strengths and weaknesses of the LON-CAPA system as it is used in this class?

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