ACTIVE LEARNING IN THE PHYSICS CLASSROOM

by

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Learning

Research Teaching

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C I R T L

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Chapter 1

Teaching Philosophy

Teaching is something I have always been able to do. Some would say it is in my blood and in the course of my life I have discovered that to be a teacher one has to be humble. They have to accept their weaknesses and embellish their strengths. A strong teacher has to realize that their profession is a constant work in progress and when they do, they need to accept that they are good enough to lead. A teacher's abilities improve, as most things do, with practice. Much later on, when they have more experience, and they are wise beyond their years a teacher can then look back on their body of work, and then they can say, I think I did a pretty good job. A friend of mine once told me that one teaches, to learn. I must have taken that to heart in my first teaching experience because I was humbled greatly by the things I did not remember, or simply did not know. At the same time, however, I marveled in all that I was learning again, or maybe for the first time. I cannot imagine that ever changing. To me, a teacher needs always to be humble in the face change. It is my sincere belief that if one accepts that they do not know everything in the world and they will learn as much from their students as their students will learn from them. Mutual learning occurs and young minds, as well as old, blossom as a result of the effort.

The greatest gift a teacher can give their students is not a supreme mastery of physics. Simply because this cannot occur in one semester, a year or even four. The greatest gift a teacher can bestow is the ability to acquire knowledge and the passion that goes along with it. A teacher guides direct and motivates young minds. When a student leaves a class I have taught they will have been challenged; they will have been pushed to their limits and they will either love learning physics or know it is not their path.

When I look back at my Delta Internship experience, I feel as though my journey is just beginning. I am now coming into my own and realizing all that I have to offer. I love physics, I loved every aspect of it, and I love teaching it. I want all of my students to feel that love; I want them to know my passion and at the end of the day I want them to find their passion for learning as well. To achieve that end, it is my belief that incorporating aspects of active learning into my methodology of teaching will benefit my students more than any other method of teaching. Active learning engages students in learning. It makes them an active participant in their future, and when the students realize how much they are learning because of it, they will be motivated, and they will be more invested in their learning. Briefly I would like to give a basic introduction to active learning and the basic tenets of the method.

1.1 Active Learning:

Active learning requires students to perform activities during a class period that enforce what they have learned. It concentrates on students spending a great deal of time thinking and concentrating on what they have just learned as opposed to writing it down and trying to learn the material on their own[1]. While this 'method' does not eliminate the benefits of self-study and activities like homework, it allows a greater *conceptual* understanding of the material. This is because one can think more about what they have been taught and they have the teacher present to ask questions to immediately. Active learning employs one or more of four different strategies and these strategies are used in what can be loosely termed sub-methods of Active learning[6]. These strategies are talking and listening, reading, writing and reflecting and they are used in the sub-methods, collaborative learning[2;7], cooperative learning[3;4;5] and problem-based learning.

1.1.1 Strategies

These strategies include but are not limited to, talking and listening, reading, writing and reflection. They are used interchangeably throughout all sub-methods used in active learning.

1.1.1.1 Talking and Listening

One of the main components of active learning is the fact that the professor does not lecture for more than 10-15 minutes at any one stretch of time. This I feel is the ideal method for a lecture because the attention span of most students does not last longer than this 10-15 minute period. To supplement the short time taken to lecture students are encouraged to discuss topics in a group setting. This allows them to work out, on their own, what the meaning of what was just taught to them is. This can be a very effective method of teaching because it allows the students to think for themselves and to formulate solutions on their own.

1.1.1.2 Reading

The reading part can encompass the reading and comprehension of material being taught. In a traditional sense, the student would read the material before lecture, and then they would attend the lecture to have the material re-enforced. One of the issues with this method is that students are not shown effect methods of reading, so more often than not the reading fail to achieve their desired effect. There are many active learning exercises that concentrate on effective reading methodologies, and these can be used to great effect in the classroom.

1.1.1.3 Writing

Writing provides students with the ability to comprehend information in their words. This can be crucial in allowing students the time and ability to formulate their conclusions based on what they have been taught.

1.1.1.4 Reflecting

Another advantage of active learning techniques is that students are given ample time to reflect on what they were just taught. In an active learning classroom, students are given time to reflect and discuss issues with their classmates. In essence, these students are teaching themselves.

1.1.2 Sub-Methods

The following methods are stand alone techniques used in teaching material. They all, however, do fall under the umbrella of active learning and as such they need to be defined and their connections to active learning need to be made.

1.1.2.1 Collaborative Learning

Definition: Any strategy used that involves students working in smaller groups (2-5) towards completing a given task. The students are evaluated on a group by group basis.

This method is one of the back bones of active learning and is very similar to cooperative learning.

1.1.2.2 Cooperative Learning

Definition: Any strategy used that involves students working in smaller groups (2-5) towards completing a given task. As a contrast to collaborative learning, students are evaluated on an individual basis.

1.1.2.3 Problem-based learning

Definition: A method that involves students being introduced to a relevant problem at the beginning of a learning section for the purpose of motivating the learning of the material.

This method is broadly used in most lecturing styles used today by a large percentage of the teaching body. However, it can be used in active learning as a motivation for group or individual work being done.

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Chapter 2

Physics Teaching Philosophy

To me, physics has to be experienced. It has to be touched and tasted and smelled. One has to bathe in it, to have it flow all about them. The entire body of knowledge know as physics cannot be learned in a day, a week, a year or even a lifetime. You have to experience physics and to do that you have to dive in head first. To me physics is not hard to understand, it is just hard to teach. It just does not work to have someone sit in front of a classroom and talk at you for hours on end and expect to gain any insight. People have to think for themselves to understand it on their own. True understanding cannot be given to someone, one honestly has to go out and take it.

This is my belief that to learn physics you first have to abandon this notion that you will ever at any point fully understand it. What a person needs to realize is that the process of learning is accumulation and assimilation of knowledge. Towards that end, I believe that what fully separates physics from other disciplines is that it allows someone to solve a problem when he or she do not know how to solve a problem. To further describe this statement let us look at problem-solving as a whole. We can break up the process of solving any problem into two phases. The first on being the set-up of the problem, the second being the completion of the set-up to get an answer. A physicist is a master of the set-up of a problem. We are learning how to set-up a problem when no body else knows how to set-up the problem. The process of learning how to do that is what physics is all about. It is a fascinating field of study and it is the main motivation behind why I want to teach. To let students experience the fascination and wonder that I do when I solve problems that I previously could not solve.

2.1 Physics is a process, and that process needs to be understood.

You cannot expect to become an expert by having someone else tell you how to become an expert. The hard work has to be put in. To me, physics is the ultimate science, the final frontier because it forces you to come face to face with the unknown. It shows you how to conquer that fear associated with the unknown. Confronting the unknown is like trying to solve a problem. Physics informs your decisions, and it tells you how to make the ultimate discoveries.

Moreover, with that rousing introduction, now it is time to be brought back down to earth. There is a process to solving problems. It is my belief that this process is universal, and I like to refer to them as recipes. Every problem one encounters in physics has to be solved this way. Even simple problems go through this process; the only difference is for simple problems many of the steps are obvious as to what one should do. More difficult problems make following the recipe a necessary part to obtain desired results. The process goes as follows,

2.2 Physics has an underlying complicated simplicity.

What is meant by this is that the most confounding concepts in all of nature have been explained in many simple ways by using the fundamental laws of physics. One can break a very complicated problem up into smaller, much simpler, components. Thus enabling one to tackle a problem that they once thought intractable.

By showing students the most general ways to tackle problems, one empowers them with physics! These are weapons used by the most seasoned physicists on a daily basis.

This concept is first introduced when vectors are introduced. One sees that these complicated formulas can be broken down into a system of less complex formulas. This system can then be used to solve problems. It is the first of many introductions to this crucial concept.

2.3 My life experience has given me a unique insight.

I love physics; I have since I was a little boy. I like to bring that passion and energy into every question answered, and every problem solved. I like to give students options, to show them that there are multiple ways to solve any problem, and I believe this gives a student their best chance to succeed. Throughout my life, I have come to know this subject from a unique perspective. I have always had a gift for seeing solutions to problems when nobody else could. I have had the ability to think outside of the box, and to take the path least traveled. It is from this vantage point that I want the world of physics to be introduced to my students. I went back to school much later in life when I was thirty-two years old. After being out of school for ten plus years, I chose physics as my major which is arguably the most difficult undergraduate degree to obtain. I took much hard work and perseverance to be where I am today. That desire to succeed no matter the obstacle does not set me apart from anyone else. It simply means that after all of this time I have conquered the inner fears I have. I have climbed that mountain before me, and I come out on the other side.

Bibliography

Chapter 3

The Three Pillars of the Delta Program

3.1 Teaching-As-Research

> ”Applying Research methodsidea, experiment, observation, analysis, and improvement to the challenge of teaching. This brings the skills of research faculty to the ongoing investigation of student learning. Promotes innovation in teaching and measurement of student learning and advances the role of instructors in the ongoing improvement of teaching practices[1].”

Research has and always will be an evolving process. One has to formulate an idea (hypothesis), and then formulate how that idea can be tested. Through the testing of this idea conclusions to its validity, or lack thereof, can be ascertained. This is the main focus of Teaching-As-Research. To tests the limits of the effectiveness of teaching. The effort to improve the passing of knowledge from teacher to student has been an ongoing process that continues to evolve and improve. The purpose of this teaching portfolio is to add these efforts to the vast body of knowledge known as Teaching-As-Research.

3.2 Learning Communities

”Through collaborative activities and programs a community of graduate students, postdoctoral researchers, and faculty is created that will: Support and validate growth in teaching and learning and Create a foundation for institutional change[1].”

Learning communities takes on several meanings. However, to me it signifies the group that one associates with that gives them the best chance to learn the material being sought. The purpose of learning communities; to make learning a group effort and to enable one to tackle difficult ideas in a systemic and proven method. Communities can be as small as a group of students within a class or as large as an ethnic group within a given city. These communities span a wide range of social and economic backgrounds and in many instances are the cornerstone for the dissemination of ideas.

3.3 Learning through Diversity

”Recognizing the common challenges in teaching and learning and the strength in bringing together diverse views. This involves interdisciplinaryserving all science, engineering, and mathematics departments. Cross-generationalbringing together graduate students, post-docs, and both new and experienced faculty. Comprehensiveproviding knowledge, practice, and community. Responsivereflecting the broad range of responsibilities that face today’s faculty and inclusivewelcoming for a multifaceted and diverse group of people[1].”

The fact that people do not all grow up in the same place means that everyone will have a different background and experience upon entering a classroom. This fact of learning can be utilized to improve the ability of a teacher to impart knowledge onto their students. Different backgrounds bring different opinions. Different opinions bring about varied ways to approach and look at a problem. It is the diversity that needs to be taken advantage of when teaching a subject.

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[1] Delta Program. Website, December 2014. URL `http://delta.wisc.edu/About/delta_pillars.html`.

Chapter 4

Teaching as Research:

At the center of teaching and learning is the overwhelming need to ascertain what exactly a student has learned. To determine this, data must be obtained, results must be analyzed, and conclusions must be reached. This is research, in a nutshell, and it gives STEM instructors the ability to hone their skills. The process of teaching as research gives one the ability to become not only the researcher but the learner as well. What Teaching-as-Research involve is the following: A deliberate, systematic, and reflective use of research methods the not only develops but implements a teaching practice whose overall goal is to advance the learning experience and improve the outcomes for students and teachers alike.

Studies have demonstrated that in general the lecture/homework/exam process is not the best way to teach physics[3;5;9;10]. With this in mind the introductory Physics class, Survey of Physics, was taught using active learning techniques. Active learning is a technique that involves student based discussions and group problem solving in class. Evidence of the effectiveness of active learning can be traced back to a study done by Hake in 1998,[5] in which traditional lecture-based instruction was compared to active learning. The improvement on the learning and comprehension was increased by a factor of two over traditional lecture-based techniques.

In this class, the use of active learning manifested itself in the classroom discussion. Much of the class was taught using in class time for problem-solving, and discussion of content presented.

4.1 Artifact I: Teaching as Research Question:

The research question for this project is as follows: *What is the best method of implementing active learning into an introductory physics class?* Active learning involves student-driven discussion and in-class problem-solving. There is not a consensus on what the perfect method of teaching is. Active learning as a whole encompasses so many sub-methods that it is nearly impossible to state that one method fits all because we all know it does not. However, one can emphasize one particular strategy over another and employ that method to the best of their ability. To evaluate active learning in teaching this introductory physics class I used the following.

- Student assessments after lecture period to determine what was not clearly demonstrated in class.

- Grade evaluation over the course of the semester.

This is a difficult hypothesis to evaluate because it is very difficult to quantify that someone understood something better. On the flip side, as a teacher one knows if something they are doing is going over well or not. What I learned is that if something did not go over well with the students they will not, most of the time, tell you that it did not go over well. However, if something did, in fact, go well, just about every student to a person will indicate this when asked about it afterward.

Grade evaluation was done over the course of the semester. It is compared on a week to week basis. Because every test is different, it is difficult to evaluate performance and ascertain improvement. However, statistically this can be done. Grades did improve steadily from the beginning of the class up until the very end.

4.1.1 Methodology:

Throughout the entire semester, I would lecture for a maximum of fifteen minutes at any one stretch of time. In *The Effective Efficient Professor* Wankat[13] cites many studies that have come to the same conclusion, that student only have an attention span that lasts at most fifteen minutes. Also a study by Hartley and Davies[6] showed that after the fifteen-minute mark there is a dramatic drop in the retention of the material being presented.

After this fifteen minute period I would, stop the lecture and begin problem-solving with an emphasis on what was taught. This is without question the hardest part to implement in active learning. This is because one cannot just simply pick any activity. These activities need to be relevant and promote the concepts being taught[2;4;12;14].

The main reason for this period of group work and activity is to allow students the chance to apply what they have just learned on their own and if they are confused or have any questions regarding the activity the teacher can address them on a case by case basis[1;7;8;11]. The largest issue that was very difficult to overcome was that the normal 'example' problems that a teacher would solve to show how problems are solved would not be done by me on the board. I would have the students figure out how to solve this problem. One can imagine how 'resistant' to this many students were but it was the method I chose, and I stuck to it.

The following format was used to teach each lecture.

- 15 minutes maximum for teaching a concept.
- 15-30 minutes for working problems dealing with the concept.
- No example problems, all work is done by the students themselves. Examples are only given for very difficult concepts.
  - Most in-class time is spent applying the information just covered.
  - Physics is learned by doing not by watching. Students work in groups and work on in class assignments.
- There is no homework that is turned in for a grade. The homework has been replaced by Quiz Prep.

One of the biggest changes was not having graded homework assigned but instead giving quiz prep. This had various results. At first the students liked the idea of having no homework but this brought about a profound lack of studying. Out of sight, out of mind I like to call it. If you do not have a deadline staring you in the face, most of the time the student is not going to put forth the effort. Once the students started to understand how much better they would do on the quizzes if they studied for them.

The basic outline of quiz-prep is as follows,

- 10-15 problems that are uploaded every Sunday online.
- These problems are the study guide, and every Friday a quiz is given that covers the quiz prep.
  - 2-3 of the quiz prep problems are given for the quiz.
  - Numbers are changed, but the problems remain the same.
- The problems for exams are sampled from the quiz prep problems not given on quizzes.

In addition to quiz-prep, handouts are given for each major concept. The purpose of these handouts is to reduce the amount of reading and to focus the students attention on specific concepts that should be taken away from this class. The overall theme of this class is that the majority of the work is done in the classroom with minimal external work done in comparison.

At a community college, many of the students are nontraditional students. They have full-time jobs, they have families, many of them have not been to school in many years. This has to be taken into account when the material is introduced. To achieve this goal the design is to minimize the work done outside of class so that the class is not overwhelming. At the same time, however, enough work needs to be done so that the students can understand the concepts and work problems.

The idea of not having the homework graded did not go over as well as I had hoped. Many students, despite the obvious benefits, would not do any work unless compelled to because of a grade. With this being the case, the adjustment that I eventually made was having the homework prep count as part of the quiz grade. I had six to ten problems assigned for quiz prep and when quiz day came students hand in the assignments, and I would grade one to two of the problems completed. This did force the students to do their quiz prep and, as a result, this produced better quiz grades.

4.1.2 Evaluation:

Students were evaluated by their test scores and the effectiveness of the teaching of concepts. At the end of each class, the students were asked what was the most confusing point covered in class. This is a qualitative measure of how well the concepts were being instructed. A few samples of the initial responses are given below,

- ”I do not understand what it is I do not understand and when I understand what I do not understand I will let you know what I do not understand.”
- ”I hate doing the math. Can you teach us the physics without the math?”
- ”Can you do more examples please?”
- ”You skip many steps in the math, can you slow down and show all the steps.”

Initially, it was a tough sell for the active learning method. Many of the students were used to the traditional style of learning and did not at first want to come around to the active learning methods. After a few weeks passed, and I became more comfortable with teaching in this style, there was a noted improvement in the students comprehension and appreciation for this new style of instruction. The main purpose of asking the students what was the most confusing point was to help structure the lecture for the following class period.

4.1.3 Grade Comparison: Active vs. Traditional Lectures

To evaluate the effectiveness of active teaching methods as opposed to traditional lectures, I would give active learning lectures for one week and then I would give a traditional lecture for the next week. At the end of each week, I would give a quiz on the material covered. The average grades on the quizzes were recorded for the active and traditional lecture weeks.

Lectures	Quiz Grades:					Average
Active	81.4	88.3	92.6	68.0	76.1	81.3
Traditional	63.8	66.7	76.3	76.4	78.3	72.3

While each quiz was over the different material and there were areas that each student excelled and struggled in respectively, it was my finding that the students seemed to enjoy the active learning lectures more. The students, on average, scored better during the weeks where the active learning lectures were given as opposed to the traditional lectures.

4.2 Reflection: Artifact I

It is my sincere belief that teaching physics via active learning is the best route to go. Active learning can accommodate a wider variety of students, and this is crucial especially at a community college where the students one has to teach are always going to have a very wide variety of backgrounds. I have come to realize, from my personal experience as a physics student, that many of the tried and true methods of teaching physics just simply do not work in the current classroom environment. To me, the key to teaching is capturing a students attention and keeping it for as long as possible.

The evaluation of the active and traditional lectures was performed because I felt this was the best method of evaluation for the effectiveness of active learning. Ironically the students were more comfortable with the traditional lectures. Often complaining bitterly when they had to get up and more around and do some activity they felt had little to do with physics in general. I am a firm believer that the sub conscious mind works on problems even when you are not working on them. I have lost track of the number of times I have gone to bed without having solved a homework problem of my own only to wake up the next morning and have the answer just 'come out of nowhere'. I can hypothesize that the alternative methods of showing the data resonated with some people that the traditional lectures just simply were not. It seemed that as long as I could give the material in more than one way, preferably three, the students seemed to get a good grasp of the material.

This is a different time and a different age, and people have many different motivations. Some can argue that physics is an impractical subject and that the study of it does not lead to gainful employment. I beg to differ on this front because I believe that physics in and of itself can motivate people to excel in many different areas of expertise. It is the one field that emphasizes and rapidly develops critical thinking. Critical thinking is universal, and it allows someone that is very skilled in this area to thrive in many different professions. There does not exist a science that does not require some ability to think critically. Active learning does emphasize critical thinking and is a natural avenue for teaching physics to the a novice and untrained mind.

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Chapter 5

Learning Communities

> ”Learning Communities bring people together for shared learning, discovery, and the generation of knowledge. Within a learning community (LC), all participants take responsibility for achieving the learning goals. Importantly, learning communities are the process by which individuals come together to achieve learning goals. These learning goals can be specific to individual courses and activities, or can be those that guide an entire teaching and learning enterprise.[4]”

The cornerstone of active learning is bringing the classroom together and having the students teach themselves. The classroom needs to be viewed as a learning community, one that involves contributions from all parties involved. This is essential to understanding problem solving because one does not know every method of solving problems. However, one does have the ability to learn from others. Working in groups is an essential activity, it is of the utmost importance that a concise method for solving problems is presented to students before any solving of problems can be beneficial. Chi et. al[2] states that experts teach how problems are solved by giving quantitative methods to the students so that these methods can be followed and solutions can be obtained.

To achieve this, I would implement in my lectures ’recipes’. These are step-by-step strategies for solving problems. If this were an engineering class, these steps would be absolute. One would follow steps A through Z, each one in order, and reach the final answer. Physics, however, is very different. It is different because each step is not unique. There are many ways about getting through the steps. These methods evolve and are different for each problem. It is one of the biggest issues with teaching physics to students that have no experience with the methods involved. There is a large body of research on this particular subject in teaching physics. For a deeper discussion on the topic, the interested reader is directed to the following citations[1;3;5].

5.1 Artifact II: The Method

5.1.1 Learning through ’Recipes’

To bake a cake, one has to follow the recipe. If one strays from the path, the results are often disastrous. There is, in fact, a recipe for solving Physics problems. I cannot make the claim that this is an easy recipe to follow. I only claim that if one follows it they will obtain correct results.

As was stated earlier each step is not the same for every problem, and that is one of the reasons physics is such a difficult subject. One has to learn each of these steps at a very basic level. It is very similar to building a strong foundation before you construct a house. The basic steps I taught are as follows,

- Set-Up
- Physics
- Math

5.1.1.1 Set-Up

For basic physics problems (as well as many more advanced problems), the Set-up encompassed (but is not limited to) the following.

1. Read the entire problem first.
2. Determine what the problem is asking for.
3. Explicitly write down what you know.
4. Explicitly write down what you do not know.
5. Determine if the unknown quantities can be determined from the known quantities.

For most problems, these steps can be done immediately. At least steps one through four. Step five, on the other hand, is often not quite so obvious, and it is the step that takes practice to master. Step one seems like an obvious first step, but you would be surprised at how many students fail to read simply the entire problem before they get started. I have been guilty of this very thing in my studies, and I know it can be hard. In the future, I should emphasize that you should read the problem two to three times before you get started. The next step is crucial and so basic many students do not do it. Often a problem can be made very simple if you first identify what you are being asked to find. There are times when the answer is so obvious that if one first asks what they are being asked to find, the solution to their problem become very apparent. This simple step is the quickest connection between the physics of the problem and the math. If a problem is asking you to find the force exerted on an object, you can immediately write down the formula $F = ma$. By doing so, you are now in the realm of mathematics. This statement tells you that you need to find the mass and the acceleration of an object. Once this has been done, you go to the next step. You explicitly write down everything you know. In this case, while you are writing down everything the problem tells you from the outset, in your mind you know that you have to mass, and acceleration and if you do not have these quantities does the problem give you a means of finding them.

I sometimes refer to this as reverse problem-solving. Looking at the end of the problem first and working your way backward. While this does not always immediately lead to a solution, it is an excellent way of setting up a problem. The method is almost completely general but there is a very wide range of problems that this can be applied to that will allow you to begin a problem.

5.1.1.2 Physics

The physics components of a problem are often very obvious. That being said, it is often the tendency of not reading problems correctly that leads to improperly setting problems up. By doing this, the basic physics of the problem can often be completely missed. Physics is the study of change. Physics embodies the relationship that physical quantities share with one another. These physical relationships that tell us how a change in one physical quantity is equivalent to a change in another physical quantity are the background for how all problems are solved.

The thing about problems is they explicitly tell you what physics is involved. It is up to the practitioner of physics to determine what these physical relationships are and what they can tell us. In classical mechanics, there are often some basic steps that can be taken during the set-up phase that will allow one to determine all the physical processes that are at play.

To begin with setting up a classical mechanics problem, the following questions can always be asked.

- Is motion occurring(Dynamics)?
- Is the system in equilibrium(Statics)?
  - In either case always draw a picture of what is going on in the problem.
  - Isolate the 'body' to be analyzed. Determine what external forces are acting on the body. (Gravity for example) From this analysis determine all the forces that come about because of this external force. Friction, Reactions, etc...
  - If the object is moving write down the equations of motion using $\sum \vec{F} = m\vec{a}$.
  - If the object is not moving write down the equations of motion using $\sum \vec{F} = \vec{0}$.
- Can I use the conservation laws? The answer to that question is yes. What are the conservation laws that can be used?
  - Conservation of Energy.
  - Conservation of Linear and Angular Momentum.
  - Work - Kinetic energy theorem.
  - There are more, but these are the basic ones.

Sometimes these steps can be painfully simple. If the motion is one-dimensional for example and there is only one force acting on an object. This can be a trivial situation and writing down all of the physics is easy. Problems like these often fool students into thinking they can solve many problems in their heads without going through all of the steps. It is my job as a teacher to convince these students that following the recipe is the only way to solve the problem at hand.

5.1.1.3 Math

Many students seem to take great joy in proclaiming to the heavens that math sucks and is no fun. While I am certain even physics students that enjoy math shout this out when they get to this step, it does not negate the necessity of the step. Thus being good at the basic math involved in solving problems can be viewed as the most important skill. If parts one and two are done correctly, the third part is simply math. For the class, *Survey of Physics* the following mathematics subjects were used extensively,

- Algebra.

- Vector analysis.
- Solving systems of equations.
- Trigonometry.

The need for a basic competency in these areas goes without saying. However, it is often the case that students fail to realize just how important these skills are. This was the biggest problem faced in the class I taught. The lack of mathematical skill was shown from day one, and it was an uphill battle. I only spent two lectures on the math and in hindsight I should have spent more time.

5.1.1.4 Fewer examples, more Work.

Examples in physics can be a double-edged sword. While they do help, a student sees how to implement a recipe they do have the tendency to make a student believe a problem can only be solved that way. In my class, I only ever gave one example of a concept and then students were broken up into groups so that they could get practice applying the recipe. Constant repetition is the only way I know of to learn concepts in Physics. It is never enough to see a professor solve a problem on a board; one needs to solve problems themselves. To work out all the math, describe all the physics. This is probably the most difficult thing about learning physics, applying recipes. However, once this skill is obtained one finds there are very few problems they cannot solve.

5.2 Reflections on Artifact II:

Teaching physics is a challenge. It is more of a challenge than I ever thought it would be. The biggest lesson that I took away from teaching physics was that I seemed to learn more from the process than my students did. The understanding that I now have of many of the basic physics concepts astounded me. The realization that I did not know many concepts nearly as well as I thought I did was an eye opener. Teaching in such a way, using 'recipes', in my opinion makes it much easier for a student to understand the basic process of problem-solving.

As I said, earlier physics as a whole is not difficult to understand. It is difficult to teach, and the main reason for this is because simply stating a concept is not enough to gain understanding. You need to learn how something is applied in real life. To do that the tried and true single best method is to solve problems. The issue comes about when as a teacher you have to instruct the students on how to solve problems. This is where the difficulty arises. In this regard, physics is tough. There just is not one way of solving a problem.

I know this method needs more development and also that these 'recipes' can sometimes be very vague and difficult to follow. However, they are also a starting place. Getting started on a problem is often the most difficult obstacle to overcome. It is my belief that this method gives the students the ability to get started and think their way through a problem.

5.3 Artifact III: Quizzes, Tests, and write-ups

5.3.1 Quiz Prep, Quizzes, Exams and Handouts:

Each week a new quiz prep was assigned. The purpose of the quiz prep was to prepare students for the quizzes that were given each Friday. These were not graded in the beginning. It was necessary to give students practice for what they were learning. This was not the most effective strategy because the students simply would not do the work because a grade was not attached to it. This in turn made the quizzes rather difficult to pass. Eventually, I had to make it such that the quiz prep was turned in with the quiz. I would great only a couple problems to make sure everyone did every problem. This was a much more effective strategy. Exams were based on the quizzes taken, and the handouts were the readings that correspond to the lectures and quiz-prep. I have selected one quiz prep, quiz, exam and handout as an example.

MADISON COLLEGE

SURVEY OF PHYSICS FALL 2014

Quiz-Prep Kinematics and Forces

Name: ____________________ *Date:* ____________________

$s = vt$
$\Delta v = at$
$v_{ave} = \frac{v_f - v_i}{2}$

$a = \frac{v_f - v_i}{t}$
$s = v_i t + \frac{1}{2}at^2$
$v_f = v_i + at$

$s = \frac{1}{2}(v_f - v_i)t$
$2as = v_f^2 - v_i^2$
$\pi \simeq \frac{22}{7}$

1. A car's odometer reads 33,401 km at the start of a trip and 34,076 km at the end. The trip took 25 hours. What was the car's average speed in kilometers per hour? In meters per second?

   v_{ave} = 27.0 km/hr, 7.5 m/s

2. A runner travels 2 laps around a circular track in a time of 66 sec. The diameter of the track is 63 meters. Find the average speed of the runner.

   v_{ave} = 6.0 m/s

3. A truck starts from rest and moves with a constant acceleration of 5 m/s^2. Find its speed and distance traveled after 11 sec has elapsed.

   v_{ave} =27.5 m/s, Δs = 303 m

4. A body with initial velocity of 8 m/s moves along a straight line with constant acceleration and travels 640 meter in 40 sec. For the 40 sec interval, find
   (a) The average velocity.
   (b) The final velocity.
   (c) The acceleration.

   v_{ave} = 16.0 m/s, v_f = 24.0 m/s, a = 0.4 m/s^2

5. A plane starts from rest and accelerates along the ground before takeoff. It moves 600 m in 12 s. Find
   (a) The acceleration.
   (b) Speed at the end of 12 seconds.
   (c) Distance moved during the 12^{th} second.

   a = 8.3 m/s, speed = 50 m/s, Δs = 95.5 m

6. A train slowing to a stop has an average acceleration of -3.00 m/s^2. It its initial velocity is 30.0 m/s, how far does it travel in 4.00 s? (Assume the motion is one dimensional)

   Δs = 96.0 m

7. An automobile accelerates from 67.0 km/h to 96.0 km/h in 8 sec. What is its accelerationin km/h^2? What is the acceleration in m/s^2

   a = 218 km/hr^2 = 60.5 m/s^2

8. A baseball is thrown vertically upward with an initial velocity of 25.0 m/s at an initial height of 9/5 m. How high does the baseball go? How long does it take to reach its maximum height? How long does it take for the baseball to hit the ground?

   Δs = 33.7 m, t = 5.2 sec

9. The final velocity of a truck is 74.0 ft/s. If the truck starts from rest and accelerates at a rate of 2.00 ft/s^2 after 300 ft has the truck reached it's final velocity? If the truck has reached its final velocity how long did it take to do so? If the truck has not reached its final velocity how much further does the truck have to travel and how long will it take?

   v_f = 34.6 m/s, The truck has not reached its final velocity, t = 37 sec, s = 1070 m

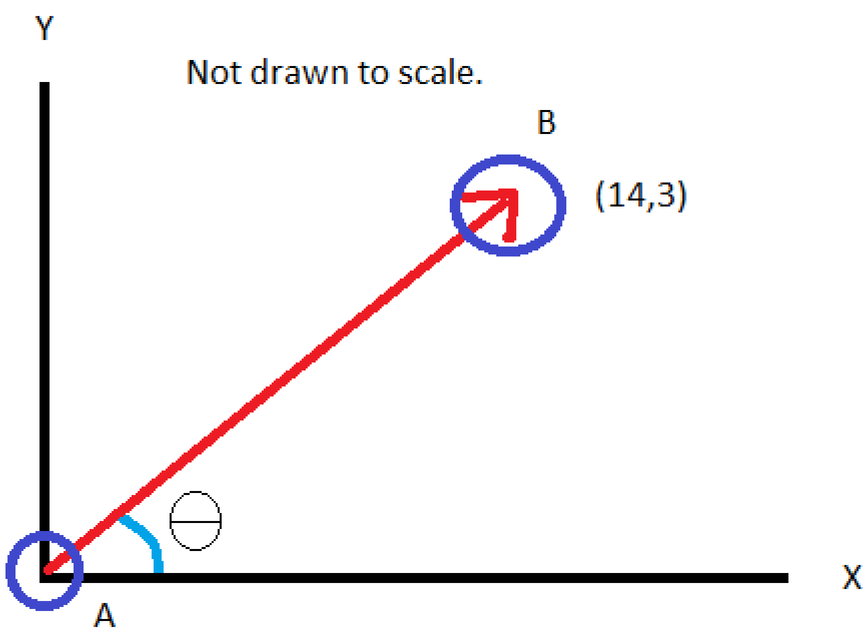
10. A car is traveling at 50 km/h. It then accelerates at 18/5 m/s^2 to 90 km/h. How long does it take to reach the new speed? How far does it travel while accelerating?

    t = 3.09 sec, s = 60.1 m

11. A bullet is fired vertically upward from a gun and reaches a height of 7000 ft. Find its initial velocity. How long does it take to reach its maximum height?

    v_i = 671 ft/s, t = 20.9 sec

12. A car travels (Not shown) from it's inital position (point A.) to its final position (point B.) in 5 seconds. Someone has decided to analyze this problem using the given coordinate system with the given X and Y axis. The X and Y components are shown for point B (assume the car starts at the origin.)



    Determine the following,

    (a) The angle θ

    (b) Magnitude of the displacement.

    (c) Assuming the car starts from rest determine the final velocity and final acceleration.

θ = 12.1°, v_f = 5.72 m/s, a = 1.14 m/s^2

13. A 12-kg box is released from the top of an incline that is 5.0 m long and makes an angle of 40° to the horizontal. A 60-N friction force impedes the motion of the box.
    (a) What is the acceleration of the box?
    (b) How long will it take to reach the bottom of the incline?
    (c) What is the coefficient of friction between the box and the incline?

    a = 1.30 m/s^2, t = 2.77 sec, μ_k = 0.66

14. Given the three vectors $\mathbf{A} = (3,2)$, $\mathbf{B} = (1,-2)$, $\mathbf{C} = (1,1)$, find the following
    (a) $(\mathbf{A}+\mathbf{B})$-$(\mathbf{A}-\mathbf{C})$
    (b) $2\mathbf{A}-3\mathbf{B}+4\mathbf{C}$
    (c) $\mathbf{A}+\mathbf{A}-\mathbf{B}-\mathbf{C}$

    a.) (2,-1), b.) (7,2), c.) (4,5)

15. A shoe is flung into the air such that at the end of 2.0 s it is at its maximum altitude, moving at 6.0 m/s. How far away from the thrower will it be when it returns to the height from which it was tossed? Ignore air friction.

    ans = 24.0 m

16. Several clowns in a circus are performing high up in the riggings of the tent. One throws a plastic bag full of water (at a height of 20.0 m) directly at a companion who is 10 m away and also 20.0 m above the ground. The bag just misses and 3/2 sec later lands on the head of a third clown. Ignoring air friction, how high is his wet head above the ground?

    h = 8.97 m

17. A flea jumps into the air and lands about 8.0 in. away, having risen to an altitude of about 130 times its own height. Assuming a 45° degree launch, compute the flea's take off speed in m/s, ignore air friction.

    v = 0.25 m/s

18. A baseball is hit as it comes in, 13/10 m over the plate. The blast sends it off at an angle of 30° above the horizontal with a speed of 45.0 m/s. The outfield fence is 100 m away and 113/10 m tall. Will the ball clear the fence?

    ans = yes, show work to prove this

19. Convert 675 rad/s to rpm.

    ans = 6450 rpm

20. A rotor completes 50.0 revolutions in 3.25 s. Find its angular speed in
    (a) in rev/s

(b) in rpm

(c) in rad/s

ans = 15.4 rev/s, 923 rpm, 96.8 rad/s

21. A flywheel of radius 25.0 cm is rotating at 655 rpm.
    (a) Express its angular speed in rad/s
    (b) Find its angular displacement (in rad) in 3.00 min
    (c) Find the linear distance traveled (in cm) by a point on the rim in one complete revolution.
    (d) Find the linear distance traveled (in m) by a point on the rim in 3.00 min.
    (e) Find the linear speed (in m/s) of a point on the rim.

    ω = 68.6 rad/s, θ = 12,300 rad, 1 rev = 157 cm, d = 3.08 km, v = 17.1 m/s

22. A bicylcle wheel of diameter 30.0 in. rotates twice each second. Find the linear velocity of a point on the wheel.

    v = 15.7 ft/s

23. A rotating flywheel of diameter 40.0 cm uniformly accelerates from rest to 250 rad/s in 15.0 sec.
    (a) Find its angular acceleration
    (b) Find the linear velocity of a point on the rim of the wheel after 15.0 sec.
    (c) How many revolutions does the wheel make during the 15.0 sec.

    α = 16.7 rad/s^2, v = 50 m/s, rev = 597

24. A well-adjusted laser beam is emitted as an exceedling narrow diverging cone of light with a typical spread of about 8×10^{-4} rad. How large a circle will be illuminated on the surface of the Moon by such a device. Distance from the earth to the moon is $\approx 3.8 \times 10^8$ m.

    area = 72.6 GM^2

25. The bob at the end of a pendulum 100-cm long swings out an arc of 15.0 cm in length. Find the angle in radians and degrees through which it moves.

    radians = 0.15 rad, degrees = 8.59°

26. A race car on a circular track goes 2.88 times around in 15 minutes. Through how many radians did it pass in that time?

    radians = .020 rad

27. A model airplane at the end of a control line circles at a constant speed 11.0 times around in 50.0 s. Through how many radians does it fly in 30.0 sec?

    radians = 41.5 rad

28. What average angular acceleration is required to stop a turbine blade spinning at 20,000 rpm in 50.0 sec?

$\alpha = 41.9$ rad/s^2

29. What is the angular speed of the 10-cm-long second hand of a clock? What is ω for the same-length minute hand?

$\omega = 1.74\times10^{-3}$ rad/s

30. A cylindrical wheel is rotating with a constant angular acceleration of 4.0 rad/s^2. At the instant it reaches an angular speed of 2.0 rad/s, a point on its rim experiences a total acceleration of 8.0 m/s^2. What is the radius of the wheel?

radius = 2 m

31. An electric circular saw reaches an operating speed of 1500 rpm in the process of revolving through 200 turns. Assuming the angular acceleration is constant, determine its value. How long does it take to get up to speed?

$\alpha = 9.82$ rad/s^2, t = 16 sec

32. Imagine two ordinary gears of different diameters meshed together, with the larger being the driver. If the larger gear has 100 teeth around its circumference and rotates at 5.0 rad/s, the smaller gear, which has only 25 teeth, will rotate at what speed?

ans = 20 rad/s

33. What force is necessary to produce an acceleration of 25.0 m/s^2 on a mass of 20.0 kg?

F = 500 N

34. An astronaut has a mass of 80.0 kg. His space suit has a mass of 15.5 kg. Find the acceleration of the astronaught during his space walk when his backpack propulsion unit applies a force to him (and his suit) of 85.0 N.

a = 0.89 m/s^2

35. A power wheelbarrow has a mass of 432 kg. What force must be applied to give it an acceleration of 1.75 m/s^2?

F = 756 N

36. Find the acceleration produced by a total force of 300 N on a mass of 0.750 kg.

a = 400 m/s^2

37. Find the mass of an object with an acceleration of 15.0 m/s^2 when an unbalanced force of 90.0 N acts on it.

m = 6 kg

38. Find the weight of an 1150-kg automobile.

$W = 11.3 \times 10^3$ N = 11.3 kN

39. Find the mass of an 11,500 N automobile.

m = 1170 kg

40. An automobile weighs 12,000 N and has a coefficient of static friction of 0.13. What force is required to start the auto rolling?

F = 1560 N

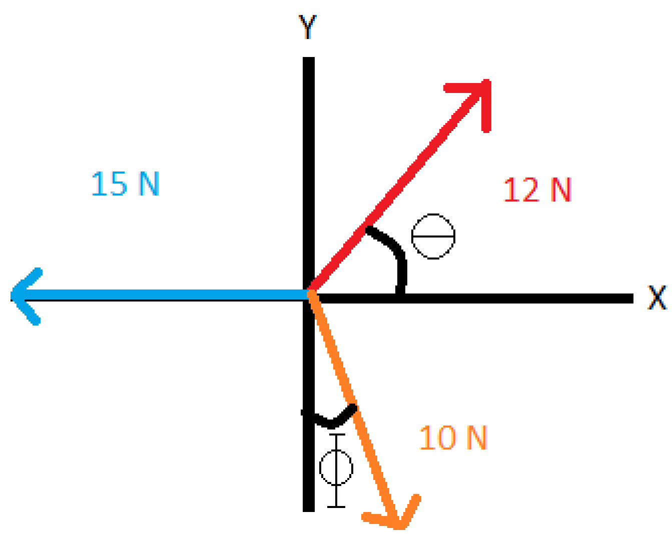
41. A piano weighs 4700 N. What force is needed to start the piano rolling across the floor when the coefficient of static friction is 0.23?

F = 1080 N

42. A cart on wheels weighs 2500 N. The coefficient of kinetic friction between the wheels and floor is 0.16. What force is needed to keep the cart rolling uniformly?

F = 400 N

43. Given the following forces,



where $\theta = 45°$ and $\phi = 30°$. Find,

(a) The resultant force in the X direction.

(b) The resultatn force in the Y direction.

(c) The magnitude of the resultant force.

(d) The angle (with the horizontal) of the resultant force.

F_x = -1.52 N, F_y = -.175 N, F = 1.53 N, θ = 6.57°

44. A light truck of mass 2000 kg is being pushed by a force of 1975 N. If the frictional force is 550 N determine,

   (a) What is the coefficient of static friction?

   (b) What is the acceleration of the object?

μ_s = 0.028, a = 0.71 m/s^2

45. A bullet fired into wet clay will decelerate fairly uniformly. If a 10-g bullet hits a block of clay at 200 m/s and comes to rest in 20 cm, what average force does it exert on the block?

F = 1000 N

46. During a parachute exercise over Alaska in 1955, a United States trooper jumped from a C-119 at 1200 ft, but his chute failed to open. He was found flat on his back at the bottom of a 3.5 ft-deep crater in the snow, alive and with only an incomplete fracture of the clavicle. Compute the average force that acted on him as he plowed into the snow. Assume the deceleration was constant; take his mass to be 90 kg and his terminal speed to be 120 mi/h.

F = 120 kN

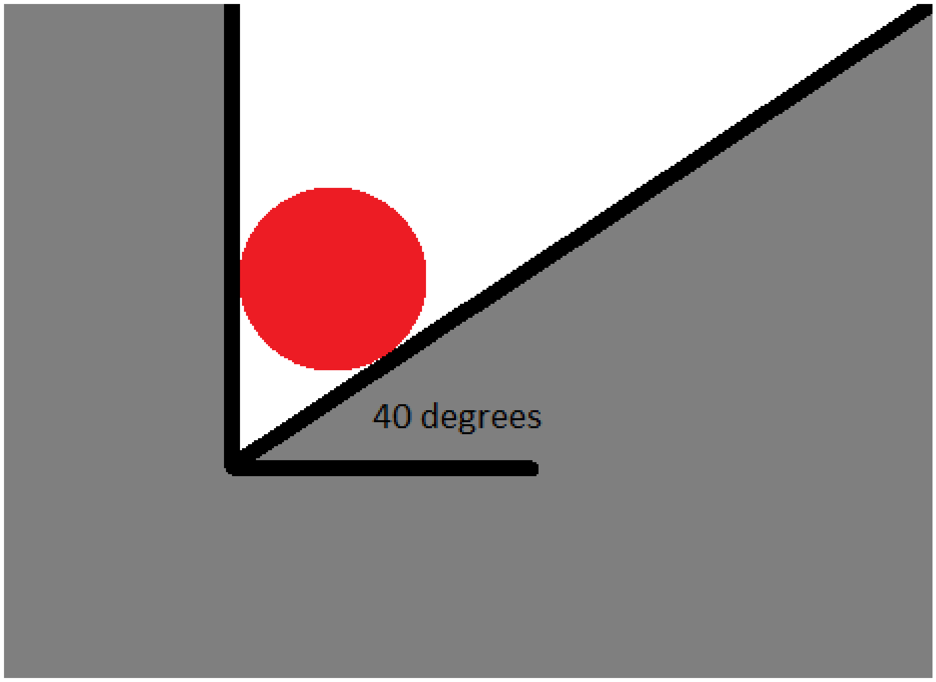
47. Someone of mass 100 kg is standing on top of a steep cliff with only an old rope that she knows will support no more than 500 N. His plan is to slide down the rope using friction to keep from falling freely. At what minimum rate can he accelerate down the rope in order not to break it?

a = 5.0 m/s

48. Harry, who weighs 320 N, and Gretchen, who weighs 200 N, are about to play on a 5.00-m-long seesaw. He sits at one end and she at the other. Where should the pivot be located if they are to be balanced?

x = 2.96 m from Gretchen

49. A sphere of mass 15.kg rests in a groove as shown,



Assuming no friction and taking the weight of the sphere to act at its center, compute the reaction forces exerted by the two surfaces.

$\boxed{N_1 = 192\text{ N},\ N_2 = 123\text{ N}}$

50. A 65-kg woman is horizontal in a push-up position. What are the forces acting on her hands and feet?

MADISON COLLEGE

SURVEY OF PHYSICS FALL 2014

Quiz I

Name: ______________________ *Date:* ______________________

$s = vt$

$\Delta v = at$

$v_{ave} = \frac{v_f - v_i}{2}$

$a = \frac{v_f - v_i}{t}$

$s = v_i t + \frac{1}{2}at^2$

$v_f = v_i + at$

$s = \frac{1}{2}(v_f - v_i)t$

$2as = v_f^2 - v_i^2$

$\pi \simeq \frac{22}{7}$

You have been alotted 15 minutes to complete this quiz. Please work on a separate sheet of paper and also please only write on one side of the paper. No calculators, cell phones or equation sheets are allowed. Make certain your desk is completely clear of everything except your quiz and the paper to write on. Box final answers and reduce all fractions. Partial credit will be given. Be certain to attempt every problem.

Question:	1	2	3	Total
Points:	10	20	10	40
Score:				

1. (10 points) A car's odometer reads 151,372 km at the start of a trip and 152,192 km at the end. The trip took 10 hours. What was the car's average speed in kilometers per hour? In meters per second?

2. (20 points) A car moves along a straight line with constant acceleration and travels 500 meter in 4 sec. The final velocity of the car is 25 m/s. For the 4 sec interval, find
   (a) The initial velocity.
   (b) The average velocity.
   (c) The acceleration.
   (d) Convert the initial velocity to mi/hr (conversion is 8 km per 5 mi). Is this a realistic initial velocity for a car to have?

3. (10 points) Factor each polymonial by completing the square (Show all work)
   (a) $x^2 + 10x + 18 = 0$
   (b) $Ax^2 + Bx + C = 0$

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SURVEY OF PHYSICS FALL 2014

Exam I

Name: ____________________ *Date:* ____________________

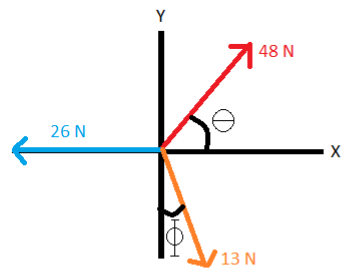
This Exam is closed book, closed note. Calculators are allowed. Your desk should be clear of everything except for a writting untensil, calculator and paper. Show all work and box in all final answers. Points **WILL** be taken off if the final answers are not boxed.

Question:	1	2	3	Total
Points:	40	20	40	100
Score:				

1. The following questions are short answer. Be as direct and to the point as possible,
   (a) (20 points) What are Newton's Three Laws of Motion?
   (b) (10 points) What is inertia?
   (c) (10 points) Why must all physical laws be invariant?

2. Answer the following
   (a) (2 points) Find the acceleration produced by a total force of 5000 N on a mass of 0.278 kg.
   (b) (2 points) Find the mass of an object with an acceleration of 17.4 m/s^2 when an unbalanced force of 87.3 N acts on it.
   (c) (2 points) Find the weight of an 1000-kg automobile.
   (d) (2 points) Find the mass of an 37,331-N automobile.
   (e) (2 points) What force is necessary to produce an acceleration of 25.0 m/s^2 on a mass of 20.0 kg?
   (f) (2 points) The bob at the end of a pendulum 100-cm long swings out an arc of 15.0 cm in length. Find the angle in radians and degrees through which it moves.
   (g) (2 points) A torque wrench reads 14.5 N·m. If its length is 25.0 cm, what force being applied to the handle?
   (h) (2 points) If 13 N·m of torque is applied to a bolt with an applied force of 28-N, what is the length of the wrench?
   (i) (2 points) A force of 112 N is applied to a shaft of radius 3.50 cm. What is the torque on the shaft?
   (j) (2 points) A belt is placed around a pulley that is 30.0 cm in diameter and rotating at 275 rpm. Find the linear speed (m/s) of the belt.

3. (a) (10 points) A baseball is hit as it comes in, 1.5 m over the plate. The blast sends it off at an angle of 37° above the horizontal with a speed of 39 m/s. The outfield fence is 119 m away and 20 m tall. Will the ball clear the fence?
   (b) (10 points) Given the following forces,



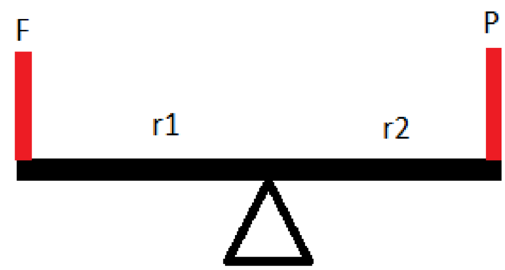
where $\theta = 31°$ and $\phi = 48°$. Find,

(a) The resultant force in the X direction.
(b) The resultant force in the Y direction.
(c) The magnitude of the resultant force.
(d) The angle (with the horizontal) of the resultant force.

(e) (10 points) A 15-kg box is released from the top of an incline that is 15.0 m long and makes an angle of 45° to the horizontal. A 40-N friction force impedes the motion of the box.

(a) What is the acceleration of the box?
(b) How long will it take to reach the bottom of the incline?
(c) What is the coefficient of friction between the box and the incline?

(d) (10 points) In the figure below Torque is being applied at both ends of the rod about the pivot point at the top of the triangle. Find the resultant torque for the given moment arms r_1 and r_2 and the given applied forces F and P,



(a) $r_1 = 2.15$ m, $r_2 = 1.50$ m, F = 25.0 N, P = 25.0 N
(b) $r_1 = 2.25$ m, $r_2 = 1.25$ m, F = 26.0 N, P = 22.0 N
(c) $r_1 = 2.50$ m, $r_2 = 1.75$ m, F = 27.5 N, P = 20.5 N
(d) $r_1 = 2.75$ m, $r_2 = 0.75$ m, F = 28.4 N, P = 20.1 N

Kinematics: Translational and Rotational

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1.) Survey of Physics
Madison Area Technical College

I. Introduction

Fundamental to all of physics is the law of **invariance**. What this means is that any proposed physical law cannot depend on the observer. A stick that is a meter long is a meter long no matter what angle the stick is being viewed at. This invariance of nature is the starting point for the physical laws that govern motion.

The study of motion without regard to the forces that cause that motion is called **kinematics**. In this paper the basic equations of kinematics will be given.

II. The Concept of Motion:

Motion is defined as a change of **position** over an elapsed time. This change in position is known as a *displacement*. For linear, one dimensional motion it is simply the final position minus the initial position,

$$\Delta s = s_f - s_i, \tag{1}$$

where Δs is the displacement and s_f and s_i are final and initial positions respectively. Motion needs to be independent of the point of view of the observer of that motion. The motion needs to be **invariant**. The need for motion to be invariant is the reason why displacements are represented by vectors. While positions are dependent upon the point of view of the observer displacements are not.

Given two positions, the initial position A and the final position B as shown in figure 1.

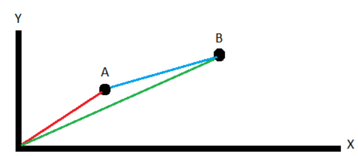

Figure 1: *Initial (A) and final (B) positions. The observer is at the origin of the coordinate system.*

The initial position vector (in red) extends from the observer (origin) to the initial position (A) and the final position vector (in green) extends from the observer to the final position (B). The displacent vector (in blue) extends from the initial position to the final position. If a second observer comes into the picture, which is sitting at the origin of the coordinate system above the initial and final positions as shown in fig 2

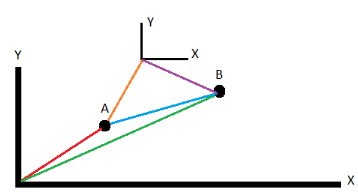

Figure 2: *Initial (A) and final (B) positions. The observer is at the origin of the second coordinate system. This shows the differences in the initial and final position vectors.*

The new initial position vector (in orange) has a completely different magnitude and direction from the previous observers initial position vector (in red). In addition the second observers final position vector (in purple) also has a different magnitude and direction of the first observers final position vector (in green). What is noted however is that the displacement vector (in blue) still has the same magnitude and the same direction. This displacement vector does not depend on the point of view of the observer, it is invariant.

III. Kinematics: Translational

What follows are the basic laws that govern translational motion independent of the forces that cause that motion.

IV. Speed vs. Velocity

Speed is defined as the ratio of the total distance traveled with respect to the elapsed time of travel. Speed is a scalar quantity. We define the speed as,

$$\text{speed} = \frac{\text{distance traveled}}{\text{time to move that distance}}, \tag{2}$$

and speed is not direction dependant. It is simply the total distance travels divided by the elasped time. **The average velocity** on the other hand is defined as the ratio of the **displacement** vector with respect to the elapsed time,

$$v_{ave} = \frac{\Delta s}{\Delta t}\left[\frac{m}{s}\right], \tag{3}$$

where Δs is the *displacement* vector, v_{ave} is the average velocity and Δt is the change in time. Remember these displacements are defined for linear, one dimensional motion. If two or more dimensions are involved, each dimension is dealt with individually.

V. Acceleration

Acceleration is the measure of how much velocity changes with respect to time. We define acceleration as,

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}\left[\frac{m}{s^2}\right], \tag{4}$$

where a is the acceleration, v_f and v_i are the final and initial velocities respectively. Acceleration is an indication that an objects motion has **changed**. This is a very important point, for velocity alone is not enough to determine if a motion has changed. *Velocity only determines if there is motion occuring, not if that motion is changing. This is a subtle but unique distinction of acceleration.*

VI. Uniform Accelerated Motion

In situations in which the acceleration of an object is constant throughout the motion there are a set of special equations that can be used for analysis. If equation (4) is solved for the final velocity the first equation of uniform accelerated motion (UAM) is obtained,

$$v_f = v_i + at \tag{5}$$

The average speed or mean speed for a UAM object is given as,

$$v_{ave} = \frac{1}{2}(v_f + v_i). \tag{6}$$

Stop now and substitute equation (6) into equation (3) and see if you obtain the second UAM equation,

$$s = \frac{1}{2}(v_f + v_i)t. \tag{7}$$

Now stop again, use equation (5) in equation (7) to eliminate the final velocity and see if you obtain the third UAM equation,

$$s = v_i t + \frac{1}{2}at^2. \tag{8}$$

Stop one last time, take equation (5) and solve for time. Now take this solution for time and substitute it back into equation (7) and see if you obtain the fourth UAM equation,

$$v_f^2 = v_i^2 + 2as. \tag{9}$$

What is interesting about equation (9) is that despite the fact that velocity and acceleration are defined as time dependant the interrelation between velocity, acceleration and position is independent of time. These constitute the equations of uniform accelerated motion. These equations were obtained through simple mathematical manipulation and no explination is given to their physical validity. That explanation is obtained through experimentation.

VII. Kinematics: Rotational

Rotational motion is displacement that occurs around a fixed axis as shown in figure 3,

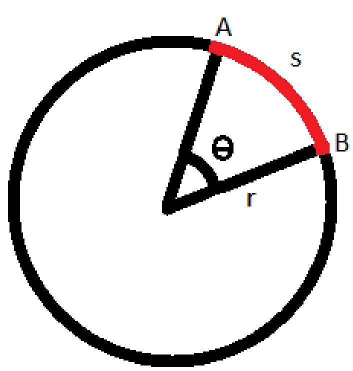

Figure 3: *Initial (A) and final (B) positions shown for rotational motion.*

The distance traveled (in red) from the initial position (A) to the final position (B) makes an arclength. We now define **angular displacement** as,

$$\Delta\theta = \frac{\Delta s_{arc}}{r}[rad], \tag{10}$$

where θ is the angular displacement, s_{arc} is the arclength and r is the radius that extends from the axis of rotation to the position of the moving object. The units from angular displacement are radians and are unitless.

One **revolution** is one complete rotation of a body,

$$360^\circ = 1\text{rev}, \tag{11}$$

and the conversion between **revolutions** and **radians** is,

$$1 \text{ rev} = 2\pi \text{ rad} = 360^\circ \tag{12}$$

VIII. Angular Velocity:

The change in angular displacement with respect to time is defined as the **angular velocity**,

$$\omega = \frac{\Delta\theta}{\Delta t}\left[\frac{rad}{s}\right] \tag{13}$$

The angular velocity can be related to the translational velocity by performing some tricky algebra,

$$\omega = \frac{\Delta\theta}{\Delta t}\frac{\Delta s}{\Delta s} = \frac{\Delta\theta}{\Delta s}\frac{\Delta s}{\Delta t} = \frac{1}{r}v_T, \tag{14}$$

With the final relationship,

$$r\omega = v_T \tag{15}$$

where v_T is the translational velocity.

IX. Angular Acceleration:

The change in angular velocity with respect to time is defined as the **angular acceleration**,

$$\alpha = \frac{\Delta\omega}{\Delta t}\left[\frac{rad}{s^2}\right]. \tag{16}$$

Similar algebraic manipulation can be performed to arrive at the relationship between rotational and translational accelerations,

$$r\alpha = a, \tag{17}$$

what is noted for angular acceleration is the same thing for translational acceleration. Angular acceleration indicates a change in angular motion. Once again an angular velocity indicates that there is angular motion.

The equations for uniform accelerated motion for rotational motion have the same form as the equations for translational motion. These equations will be summarized as follows,

- $\omega_f = \omega_i + \alpha t$,
- $\omega_{ave} = \frac{1}{2}(\omega_f + \omega_i)$,
- $\Delta\theta = \frac{1}{2}(\omega_f + \omega_i)t$,
- $\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$,
- $\omega_f^2 = \omega_i^2 + 2\alpha\theta$.

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5.4 Reflections: Article III

The biggest part of my project was the creation of the quiz-prep, the quizzes, the exams and especially the handouts. Often the lectures would be directly based on the handouts and while admittedly most students did neglect to read them those that did express a much better understanding of the material. In hindsight, I would change the format of the quizzes in the future. I would not have them relate so directly to the quiz prep. If I were to give credit for the prep from the outset, I would make the quizzes a bit more challenging.

Another option would be to drop the quiz prep all together and simply base the grade on homework and exams like what is done in a traditional physics class. I debate the wisdom of doing so because I do not believe exams are the best metric for students performance. I believe evaluation must occur through some cumulative final project or daily evaluation of progress (quizzes.) This being said my mind might change in the future. As I progress in my profession, undoubtedly my thoughts and opinions on things will change. Time makes us all the wiser.

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Chapter 6

Learning through Diversity

> ”The literacy and engagement of all students in science, technology, engineering, and Mathematics is a priority goal for U.S. higher education. Delta seeks to contribute to this goal by enabling present and future STEM faculty to enhance the learning of all students whom they teach irrespective of, but not limited to, preferred learning styles, race, ethnicity, and culture, gender, sexual orientation, disabilities, religion, age or socioeconomic backgrounds. Deltas contributions to diversity in STEM are founded on the principle that excellence and diversity are necessarily intertwined. Faculty and students bring an array of experiences, backgrounds, and skills to the teaching and learning process. Effective teaching capitalizes on these rich resources to the benefit of all, which we call ”Learning-through-Diversity.” At the same time, Delta recognizes the reality that existing social and educational practices do not always promote equal success for all learners. Thus, creating equitable learning experiences and environments require intentional and deliberate efforts on the part of present and future faculty. Delta is committed to developing a national STEM faculty who model and promote the equitable and respectful teaching and learning environments necessary for the success of Learning-through-Diversity.[7]”

6.1 Artifact IV: Bringing different perspectives into the classroom.

This Delta experience has taught me quite a bit. One of the things it taught me was just how much I did not know about teaching and how much I still have to learn. This was made quite evident in the first week of class. I was overwhelmed, and I thought I knew the best way to instruct and to motivate students. I learned quickly that I was going to gain as much if not more from teaching this class as the students were going to get from taking it.

The classroom was small with only eight students. This was a relief because my first teaching experience was not going to be in a classroom of several hundred. This gave me the opportunity to get to know each student and for each student to get to know me on a personal level. This was ideal because despite the class only having eight students most all of them came from different walks of

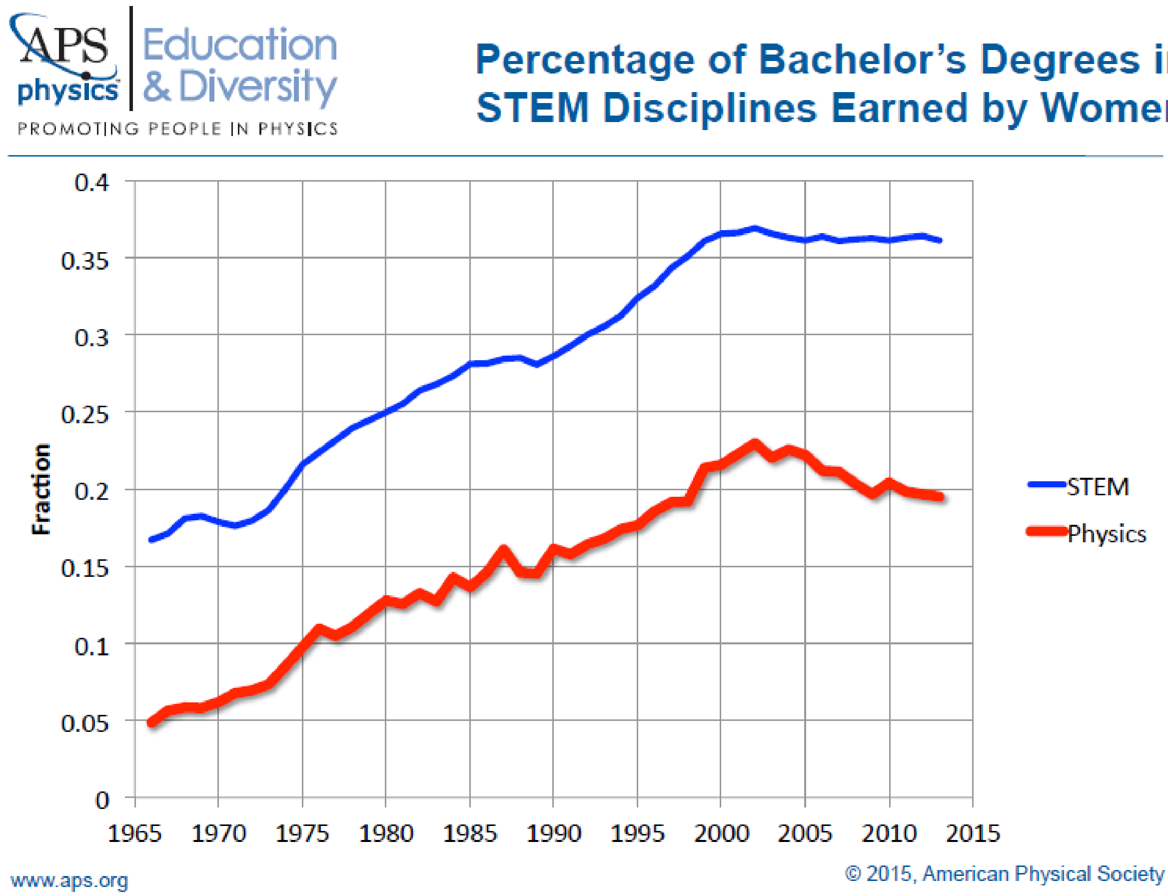

Figure 6.1: Percentage of bachelor degrees granted to women in STEM fields broken down by STEM disciplines as a whole and physics in particular[6].

life. There was one female in the class, one autistic student, one significantly older student with a family and a group that was former military using their GI Bill to get an education. Most all of them had varied math and physics skills, and the most significant challenge was bringing them all together.

There is a large gap in the learning that takes place for many students based on gender, race, and disabilities[4;5;8]. This factor must be taken into account when one is teaching any class let alone a physics class. Many women do not engage themselves in learning physics, and there are many factors that are to blame.

As shown in figure 6.1, the percentage of women in STEM fields is 36.12%, and physics, in particular, is only at 19.53% as of 2013[6]. This huge gap in learning stems from women being discouraged from pursuing this disciplines at an early age[3]. Espinoza[2] showed that many women of color persisted in obtaining STEM degrees if they were included in activities, STEM-related groups, etc. Making an all-inclusive environment for students to learn is very important in the learning environment[1;9].

The semester started out on the wrong foot and as most rookie professors I made several mistakes and often did not explain things as clearly as I should have. This changed as I settled down and was able to communicate more clearly to everyone. What mainly occurred was the stark differences in the students backgrounds and understanding of the basic math skills necessary made it paramount that I communicate on a personal level to each student. This was the most important lesson I had to learn. That everyone learns differently, and a good teacher takes account of these differences and makes the classroom better because of it.

6.2 Reflection: Artifact IV.

This teaching experience was unique. I have been told by many a professor that each class will be different and that each experience builds upon the first. The one thing a community college offers is the chance for people from all walks of life at various points in their life to come and get trained in a specific profession. This brings about diversity almost like a bi-product, and it makes the challenge of teaching these students a unique one.

One problem, in particular, that rose up and reared its ugly head happened at the beginning of the semester. The only female student in the class felt as though she was being singled out and did not like it. I did not realize what I was doing when it was occurring but in hindsight I was singling her out. She was one of the more capable students in the class, and I would often call on her to answer questions that most everyone in the class did not know how to answer. She did not know the answer to every question and when she did not I would try to guide her through to the solution. To achieve this end, I would ask for the assistance of the other students in the class for these particular steps. By doing this, she felt as though I was setting her up for failure and singling her out. This came as a shock to me, and it made me realize that you really have to take everyones feeling into account. I had to structure my lectures and teaching styles such that no body felt stupid or inadequate in the classroom. I improved greatly as an instructor as a result.

Given all of this it was a very special time for me. The semester was trying because of personal injuries I sustained (torn Achilles), and it was a bit of a challenge getting around. Despite it all I was able to complete the semester to the best of my ability and I became a much stronger teacher because of it. The different types of students made me adapt my teaching style. It made me rethink how I approach lectures and what I need to concentrate on the most. All in all, I could not have asked for a better situation or group of students.

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Chapter 7

Learning Outcomes Matrix

Associate Level	
Teaching As-ResearchAssociates can do the following:	**How this outcome was met:**
Know that a body of literature and knowledge exists concerning high-impact, evidence-based teaching practices.	Demonstrated by completing the Delta Internship. Submitted a project proposal and draft of final summative report that includes literature reviews.
Define and recognize the value of the Teaching-as-Research process, and how it can be used for ongoing enhancement of learning.	Met by completing the project proposal and final reflection of Internship.
Know how to access the literature and existing knowledge about teaching, learning and assessment, in a discipline or broadly.	Demonstrated in College Classroom course, researched the literature for an assignment.
Describe and recognize the value of realistic well-defined, achievable, measurable and student-centered learning goals.	Addresses in activities and readings on student-centered learning and backward design for College Classroom Course; course goal: Begin building learner-centered syllabus for a future course.
Describe several assessment techniques and recognize the value of their alignment with particular types learning goals.	Demonstrated through the use of artifacts in this teaching and learning portfolio.
Describe and recognize the value of evidence-based effective instructional practices and materials.	Demonstrated through data obtained in Delta Portfolio.
Describe a full-inquiry cycle	

Learning Communities Associates can do the following:	**How this outcome was met:**
Know that a body of literature and knowledge exists associated with learning communities and their impact on undergraduate learning.	This was met through the preparation of the portfolio. Through the use of referred literature to re-enforce hypothesis.
Define the characteristics of undergraduate learning communities (LC's)	Demonstrated in section 6.1 of portfolio.
Describe the impact of LCs on student learning	Demonstrated in section 6.2 of portfolio.
Describe and recognize the value of LC strategies that promote positive interdependence between learners so as to accomplish learning goals.	Demonstrated in section 4.1.1 and section 6.2 of portfolio.
Describe and recognize the value and issues of establishing LCs comprising a diverse group of learners.	Described in section 6.2 of portfolio.
Describe techniques for creating a LC within a learning environment.	Demonstrated in completion of delta internship project. The project involved teaching a very diverse class by virtue of their backgrounds. Many community college students are non-traditional students.
Recognize the value of and participate in local professionally-focused learning communities associated with teaching and learning.	

Learning through DiversityAssociates can do the following:	**How this outcome was met:**
Know that a body of literature and knowledge exists associated with diversity and its impact on accomplishing learning goals.	Demonstrated in portfolio. Many literature searchers were done to back up hypothesis.
Define and recognize the scope of diversity in learning environments, of both students and instructor.	Demonstrated not only in delta portfolio but additionally in my own experience. Being a very non-traditional student myself I recognized how difficult these early classes can be and how much effort is required to take them.
Recognize the impact of diversity on student learning, in particular how diversity can enhance learning, and that inequities can also negatively impact learning if not addressed.	In my project we had a student with autism. He was by far the brightest student in the class but at first it was hard to get students to work with him. However once they recognized how brilliant he was it was hard to get students to not work with him.
Describe how instructors beliefs and biases can influence student learning.	Early on in the project I realized that I was teaching the class at a very high level. I did not recognize that students first introduced to physics might have a very difficult time with it. Something that comes natural to me does not come naturally to most people.
Recognize the value of drawing on diversity in the development of their teaching plans (including content, teaching practices and assessments) to foster learning.	During the internship project students were very reluctant to speak up in class. My project revolved around class participation and students becoming comfortable with speaking up. I rectified this situation by providing many more group based projects. So they could work together and not have to feel embarassed speaking up alone. Additionally I had assignments where they would come to the board and solve a problem and get help from everyone in the class. I would often make it a game giving them extra credit points on the next quiz for participation.
Describe several learning-through-diversity (LtD) techniques and strategies (e.g. creating a welcoming environment, learning communities).	Demonstrated in delta portfolio.

Practioner Level:

TeachingAs-Research Practitioners can do the following:	How this outcome was met in the Delta Certificate:
Develop a deeper understanding of the knowledge concerning high-empact, evidence based, teaching practices.	This was gained from performing literature review while completing the delta portfolio.
Develop a Teaching-as-Research plan for a limited teaching and learning project.	This was done in the College Classroom course and additionally in the Teaching with Technology course.
Execute a Teaching-as-Research plan for a limited teaching and learning project.	This was done in the College Classroom course and additionally in the Teaching with Technology course.
Show the integrated use of Teaching-as-Research, Learning Community and Learning-through-Diversity to accomplish learning goals.	These techniques were learned in the College Classroom and Teaching with Technology courses. These skills were demonstrated in the delta internship project.
Learning Communities Practitioners can do the following:	**How this outcome was met in the Delta Certificate:**
Develop a deeper understanding of the knowledge concerning LCs and their impact on undergraduate student learning.	Developed a deeper understanding through the delta internship.
Integrate one or more LC strategies into a teaching plan so as to accomplish learning goals and learning-through-diversity.	Demonstrated in delta internship project and delta portfolio.
Implement one or more LC strategies for students in a teaching experience.	Demonstrated in the delta internship project.
Contribute to locally professionally-focused learning communities associated with teaching and learning.	
Show the integrated use of Teaching-as-Research, Learning Community and Learning-through-Diversity to accomplish learning goals.	Demonstrated in delta internship project.
Learning through Diversity Practitioners can do the following:	**How this outcome was met in the Delta Certificate:**
Develop a deeper knowledge of the body of literature concerning diversity and its impact on accomplishing learning goals.	Demonstrated in delta portfolio.
Examine own beliefs and biases, including how they may influence their students learning.	Demonstrated in delta portfolio.
Determine the diverse backgrounds among a group of students, and consider the opportunities and challenges of the findings on each students learning.	Demonstrated in delta portfolio and delta internship project.
Create a teaching plan that incorporates content and teaching practices responsive to the students backgrounds.	Demonstrated in delta portfolio and the courses the College Classroom and Teaching with Technology.
Integrate one or more LtD techniques and strategies in a teaching plan so as to use students diversity to enhance the learning of all.	
Implement one or more LtD strategies in a teaching experience.	
Show the integrated use of Teaching-as-Research, Learning Community and Learning-through-Diversity to accomplish learning goals.	Demonstrated in delta portfolio.