

STANDARDS-BASED GRADING A HIGH SCHOOL PHYSICS CLASSROOM

by

Erik Dane Tietzen

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## ABSTRACT

The paper investigated the effectiveness of standards-based grading (SBG) in a high school physics classroom, as well as how student perception of the importance of grades changed when exposed to SBG. Authentically assessing student performance is a controversial issue and SBG is no exception. While initially transitioning to SGB may seem easy, it actually requires a radical shift in thinking by the teacher. In order for SBG to be successful a teacher must construct a way to allow students to show growth and allow them to learn at their own pace. Giving a grade value to student assessments doesn't require much change, but the idea and weight of a zero percent needs to be reevaluated. Throughout the research process it was found that students who utilized the SGB system did perform better on a final exam as compared to previous classes that were taught under a more traditional system. Student opinion on grades also changed throughout the research period. Students realized that the more concepts they can accurately demonstrate, the higher their overall grade becomes. This gave students a measurable system to achieve the grade that they wanted.

## INTRODUCTION AND BACKGROUND

Lincoln High School is nestled along the shore of Lake Michigan in Manitowoc, Wisconsin. According to the City of Manitowoc website Manitowoc currently has a population of about 33,335 people with an average age of about 43.6 years. The median income in Manitowoc is about \$40,000 which is \$11,000 less than the state average (City of Manitowoc). Lincoln is a school for grades 10-12 and is the only public high school in the city of Manitowoc.

According to the Lincoln High School website (Lincoln), “The Lincoln High School community prepares every student to be a responsible, global citizen and lifelong learner.” Lincoln High School has also adopted a philosophy for all teachers to follow.

The first part is the big three ideas:

- Focus on Learning for All
- Creating a Collaborative Culture
- Focus on Results

My personal teaching philosophy mirrored the first two ideas by attempting to bring relevance to education and connect learning to life. Too often students sit behind desks and listen to lectures without engaging in the material being presented. I had attempted to fix this problem by adopting a modeling approach to teaching in my general physics classes. Students spent more time in group or class discussions than listening to lectures. Students used whiteboards almost daily as a tool for solving problems and sketching out their ideas. Lab activities always had a purpose and a connection to a real life situation. I

had not, however, found an assessment platform that fits in well with this style of teaching.

A way to focus on results that fits well with my modeling approach was answered by the second part of the Lincoln High School philosophy. This philosophy includes four questions:

- What do we expect our students to learn?
- How will we know when they have learned it?
- How will we respond when students do not learn?
- How will we respond when students have learned?

I felt that the best way to answer these questions was with the concept of standards-based grading (SBG). In SBG students are assessed against a set of subject specific standards. This gives students and the teacher a common understanding of the expectations of the class. If a student can show mastery of a specific standard, the teacher will know that they have understood the concept. SBG can also be used as a way to differentiate instruction. When the basic standard is demonstrated, more advanced assessments can be used to challenge students. Struggling students have the opportunity to reassess specific standards. Not everyone can master a concept in the same amount of time and this reassessment can help students who may take longer to understand a concept.

This idea leads to my focus question: how will standards-based grading affect the engagement and performance of students in a high school physics classroom? It also

leads to my secondary question of, will SBG change the attitude of students toward grading?

### CONCEPTUAL FRAMEWORK

Grading standards and policies of today are roughly the same as when the Committee of Ten discussed educational reform in 1892 (Cox, 2011). However, inconsistencies in grading have increased concern to connect instruction with grading policies (Tierney, 2011). Assessment systems to track student progress and teacher expectations of students do not align as well as they should (Wilcox, 2011). Student expectations, which are based on a set of well-defined, subject specific standards or goals set by teachers, the state, or other educational institutions are not fully compatible with an assessment system that tracks points and averages (Hooper, 2014).

At the secondary level of education, grading is largely left to the expertise of the teacher. This, however, leads to some discrepancies on a broader scale. These discrepancies can be between educators who teach the same class in different schools, or even educators who teach the same class in the same school. Each teacher has their own personal views and beliefs that can be an influential factor in how that teacher assesses students (Cox, 2011). A student may earn a low grade from a particular teacher, and with the same work earn a higher grade from a different teacher in the same subject. These differences show a clear purpose and need for educational reform. While a change may be necessary, the purpose of grading must be determined along with the beliefs and views that the teacher determines as important (Brookhart, 2011).

While teachers have established beliefs about teaching, students have established perceptions about learning and how to learn. How teachers instruct can change student viewpoints about how to learn, as well as what to learn. Teachers, when asked, want students to be problem solvers, to communicate effectively, and to be creative (Wilcox, 2011). But a point-based grading system does not foster student mastery and understanding of these goals and standards (Wormeli, 2006). When analyzing a grading system it is necessary for that system to be able to differentiate between a met and an unmet learning objective set by the teacher (Iamarino, 2014).

The most common system used in secondary education today is the 100-point scale, usually shown as a percentage (Hooper, 2014). In this system of assessment, assignments are assigned points and students earn them as they progress through the class (Iamarino 2014). The 100-point scale system has been modified over time to be what is common today. It is a system that enables teachers to calculate grades easily, and it is easy for most people to understand the general meaning. A student who has a 90% in a class is classified as doing well in that subject, but the 90% score says nothing as to what the student actually accomplished or understood. This can be an issue when attempting to determine what a student knows and does not know (Guskey, 2013).

One of the fundamental flaws in the 100-point scale system of grading is that student expectations are not always clear. Students do not fully understand the overall purpose of each assessment (Guskey, 2006). This is due to the assortment of assessments that determines student grades (Hooper, 2014). The following list compiled by Guskey (2006, p. 671) is of assessments commonly used in a traditional 100-point scale system:

- Major exams or compositions
- Homework completion
- Class quizzes
- Homework quality
- Reports or projects
- Class participation
- Exhibits of students' work
- Effort
- Laboratory projects
- Attendance
- Students' notebooks or journals
- Punctuality of assignments
- Classroom observations
- Class behavior or attitude
- Oral presentations
- Progress made

Overall these examples together do not represent mastery of a subject (Hooper, 2014). Students are clever and when given the choice of so many different assessments they will choose to spend their efforts performing the ones that give them the most points for the least effort whether learning happens or not (Iamarino, 2014).

Along with a variety of assessment types used in the 100-point scale system to calculate a final grade, the different assessments scores need to be averaged to calculate a final score for a student. This averaging dilutes the meaning the grade earned on the individual assessments. A student may have accomplished only a handful of the teacher assigned expectations for a class, but if the point game can be played well enough the student may pass the class with a high grade. If grading is a way to communicate information to students and parents about the learning mastery by the student, the percentage system is flawed (Hooper, 2014).

The flaws in the 100-point scale system do not stop with communication. This scale is comprised of 100 gradations, or levels, to a grade. A student can earn anywhere from a 0% to a 100% in a class. This many levels are unnecessary in communicating mastery of a subject. If the measuring device is not accurate enough to convey precise meaning, adding more gradations will not increase the precision (Guskey, 2013). Also, using a 100-point scale system has adverse effects on students by not allowing or fostering improvement (Iamarino, 2014). If the student earned enough points to pass the assessment, there is no motivation to go back and learn what was wrong to try and better understand the material. Student motivation was not the primary purpose of the 100-point scale grading system (Schinske, 2014). Points, therefore, are a distraction to the true meaning of learning. We are currently in a system where grades matter most, and learning is not necessary (Iamarino, 2014).

When deciding to change a grading system, the most pressing issue is consistency between teachers (Cox, 2011; Guskey, 2013). Having a consistent grading policy

between teachers who teach the same subject reduces discrepancies in what a grade actually means. Grades are an indicator of student mastery and understanding of goals and standards (Wormeli, 2006). If this is the case, then a grading system should eliminate assumptions and bias as part of evaluating student achievement (Hooper, 2014).

Standards-based grading (SBG) emphasizes student understanding rather than compliance (Wilcox, 2011). It assesses present understanding of materials and holds students accountable for their progress throughout a class. In SBG students are assessed by demonstrating mastery of the subject without regard to points earned (Iamarino, 2014). The final grade the student achieves is based on evidence of mastery demonstrated throughout the course. Instead of students being concerned with how many points the exam is worth, their attention is more likely to be directed towards better understanding a concept. While points are still utilized to track student progress, a system with fewer gradations should be used. This four-point system indicates mastery of goals set by the educator. An example of one such scale is: Below basic, basic, proficient, and advanced. Decreasing to four or five gradations clarifies the meaning of the grade and enables the instructor to better communicate with students about their progress and understanding (Guskey, 2013).

Getting students to mentally shift their focus from points to concepts takes time and energy to establish. Goals and standards need to be clearly defined and assessments created to show mastery of those standards. When determining the goals and standards, the student must remain the focus of the educator. Goals must be fundamental scientific ideas; they need to be in the form of a question, and they should build on one another as

the course progresses (Wilcox, 2011). Formative and summative assessments need to mirror this goal oriented structure. Students need a clear understanding of the difference between these two forms of assessment. Summative assessment determines the magnitude of learning and is included in the final grade and can include final projects, lab reports, tests, practical labs, and group presentations (O'Connor, 2002). Formative assessments should be used daily to gauge student progress and understanding (Wilcox, 2011). The primary purpose of formative assessment is to give timely communication and feedback to the student (O'Connor, 2002).

Whether communicating to parents throughout the school year or to a student struggling to understand a concept, feedback is crucial to SBG (Wilcox, 2011). Feedback to and from students will sometimes uncover hidden problems in curriculum or teaching style. This can be an issue when starting a SBG system in a classroom since it forces the teacher to adapt teaching techniques to address newly found issues. This can be a struggle for some teachers who are comfortable in their teaching routines and reluctant to change. However, existing activities can be analyzed and reused to better fit the learning environment and needs of the students (Iamarino, 2014).

Educators continue to use the 100-point scale system to show student progress for a multitude of reasons. The ease of averaging points and the apparent understanding by parents has almost locked this form into universal use (Guskey 2013). However, fundamentally the 100-point scale system does not accurately portray student accomplishment and understanding. SBG is a way for teachers to determine and communicate exactly what a student knows plus what they are struggling with. It also

gives students more investment in the educational process. Instead of being anxious about how many points they need to pass, students are concerned about understanding a concept, and as the class progresses they will understand how the concepts connect to one another. While converting a class to a SBG model may seem daunting, the effort will be worth the rewards of better communication with students, achievable standards, and ultimately better educated students (Iamarino, 2014).

## METHODOLOGY

The action research-based classroom project was conducted during the first semester of the school year from September 2016 to January 2017, encompassing two physics classes with students ages 16 to 18 years ( $N=35$ ). The data gathered from this project was intended to determine the effectiveness of Standards-Based Grading (SBG) in a high school physics classroom. This project was also intended to gauge student attitudes toward grading, the meaning of grades, and to promote motivation to learn. SBG was utilized throughout the entire semester, and student feedback was collected to understand attitudes and opinions on a number of different issues. These issues include the meaning and value of a grade, understanding concepts rather than earning points, and timely feedback on performance. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Before students were introduced to SBG the *Start of the Year Student Survey* was administered to the students to measure their attitude toward grading and the meaning behind a grade (Appendix B). The results of the first part of the survey were analyzed using a numbered scale of *highly disagree* (1), *disagree* (2), *agree* (3), and *highly agree*

(4) and taking the average of all responses. Each category was also compared to the total responses and the results were reported as a percentage. The percentage of each category was analyzed for trends. The percentage data from these questions was shown in a data table. The short answer responses were reviewed to understand student attitudes toward the most commonly used grading system at the time.

Near the end of the first half of the treatment period, students were given the *Midcourse Student Survey* that helped determine how their attitude toward grades had shifted (Appendix D). The results of the first part of the survey were analyzed using a numbered scale of *highly disagree* (1), *disagree* (2), *agree* (3), and *highly agree* (4) and taking the average of all responses. Each category was also compared to the total responses and the results were reported as a percentage. The percentage of each category was analyzed for trends. The percentage data from these questions was shown in data table. Students were given the opportunity to answer free response questions to what they liked and disliked about SBG. This data was used to gauge student attitude midway through the treatment to compare with the pre-treatment responses and post-treatment responses.

At the end of the treatment process the *End of the Semester Student Survey* was used to collect student responses to determine the shift in attitude toward grading practices (Appendix F). The results of the first part of the survey were analyzed using a numbered scale of *highly disagree* (1), *disagree* (2), *agree* (3), and *highly agree* (4) and taking the average of all responses. Each category was also compared to the total responses and the results were reported as a percentage. The percentage of each category

was analyzed for trends. The percentage data from these questions was shown in data table. This data was compared to the pre-treatment and mid-treatment data percentages. The free response portion of the survey was used to determine student attitude toward SBG after the full treatment was complete.

Weekly student grades were calculated and recorded to show student progress throughout the class. Standard-based grades were calculated using a 3-level system. First, students attempted to complete a C-level standard, usually representing the most basic concept that they were required to understand. Mastering this would earn the student a 75%, or C grade. Once the C-level is mastered, the student can attempt the B-level standard, earning a maximum grade of 85% or a B grade. Once the B-level is mastered, the student can attempt the A-level standard. Completing the A-level standard will earn the student a 100%, or an A grade for that standard. As long as the student attempts the C-level standard, the lowest percentage grade he can receive is a 50%. This means that the student will only need to increase his score by 10% to receive a passing grade.

The treatment was administered over two 9-week grading periods. During each grading period the students attempted to complete standards-based assessments each week. By week seven of the first and second grading period the students had access to all standards that would be assessed during that particular grading period. During the first grading period students were required to assess seven standards. During the second grading period students were required to assess five standards. Between weeks seven and the end of the grading period students could make additional attempts to complete the

required standards. The week 7 scores from the first grading period were averaged with the week 7 scores from the second grading period. The same was done with the final scores from the first and second grading period. For example, student A had an 76% at the end of week 7 of the first grading period and a 80% at the end of week 7 of the second grading period. This student also had a 90% at the end of the first grading period and a 92% at the end of the second grading period. The week 7 data would be averaged giving a 78%. The end of grading period data would be averaged giving a 91%. This information was analyzed for overall improvement by normalizing the data and looking for the difference between the time that the students had access to all standards for the grading period, or week 7, and their final grade at the end of the grading period. The mean value from week 7 and their final grade was compared to evaluate whether there was any improvement in understanding. This was done by calculating an average normalized gain. A normalized gain indicates the percentage of improvement compared to what could actually be improved upon. A low normalized gain would have a value less than 0.3. A medium normalized gain would have a value between 0.3 and 0.7. A high normalized gain would have a value greater than 0.7 (Hake 1999).

The final semester exam was also used to collect data relevant to SBG. The final exam used for the treatment group was the same as the one used for two previous years of students who were not exposed to SBG (Appendix E). The previous scores acted as baseline data to determine if the treatment had any effect on student learning. This data was analyzed using a two sample t-test to determine if there was a difference between the mean of the previous classes and the mean of the treatment class.

A minimum of three data sources were used to collect data for each focus question (Table 1).

Table 1  
*Data Triangulation Matrix*

| Focus Question                                                                                                                                                         | Data Source 1               | Data Source 2                                         | Data Source 3                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------|---------------------------------------------------------------|
| Primary Question:<br>How will<br>implementing<br>Standards-Based<br>Grading (SBG) effect<br>understanding and<br>performance in a high<br>school physics<br>classroom? | Start of the Year<br>Survey | End of the Quarter<br>Survey<br><br>SBG Scores        | End of the Semester<br>Survey<br><br>Final exam<br>statistics |
| Sub question 1:<br>Will SBG change the<br>attitude of students<br>toward grading?                                                                                      | Start of the Year<br>Survey | Teacher Interview<br><br>End of the Quarter<br>Survey | End of the Semester<br>Survey                                 |

## DATA AND ANALYSIS

The *Start of Year Student Survey* was administered to two physics classes prior to starting the treatment ( $N=37$ ). Of the total responses 84% of students *agreed* or *strongly agreed* that a class grade matches what was learned, and 92% of responses *agreed* or *strongly agreed* that a letter grade was important. Also, 87% *agreed* or *strongly agreed* that a score to show how well each idea was learned was important, and 95% *agreed* or *strongly agreed* that a list of standards to be learned would be valuable (Table 2).

Table 2  
*Start of Year Student Survey Percent per Question*

| Student Survey Question                                                     | 4 –<br>Strongly<br>Agree | 3 –<br>Agree | 2 –<br>Disagree | 1 –<br>Strongly<br>Disagree |
|-----------------------------------------------------------------------------|--------------------------|--------------|-----------------|-----------------------------|
| A letter grade for a class is important to me                               | 43%                      | 49%          | 8%              | 0%                          |
| Information about how hard I tried in class is important to me              | 35%                      | 57%          | 8%              | 0%                          |
| I understand how assignments and tests are used to figure my grade in class | 24%                      | 76%          | 0%              | 0%                          |
| A list of the standards to be learned in a class would be valuable          | 30%                      | 65%          | 3%              | 3%                          |
| A score to show how well I've learned each idea is important to me          | 22%                      | 65%          | 13%             | 0%                          |
| My grade for a class matches what I've learned in that class                | 22%                      | 62%          | 16%             | 0%                          |
| My score on tests matches how well I've learned in class                    | 19%                      | 54%          | 27%             | 0%                          |

The *Midcourse Student Survey* was administered after the first nine weeks of the treatment ( $N=33$ ). At the time of the survey 85% of students understand how the standards-based grading system grade is calculated, 82% of students are more concerned with their percentage grade than their standards, and 82% feel that their standards grade is an accurate reflection of what they have learned (Table 3).

Table 3  
*Midcourse Student Survey Percent per Question*

| Student Survey Question                                                               | 4 –<br>Strongly<br>Agree | 3 –<br>Agree | 2 –<br>Disagree | 1 –<br>Strongly<br>Disagree |
|---------------------------------------------------------------------------------------|--------------------------|--------------|-----------------|-----------------------------|
| I understand how the Standards-Based Grading system works to calculate my grade       | 52%                      | 33%          | 15%             | 0%                          |
| I am more concerned with the percentage grade than I am with the individual standards | 30%                      | 52%          | 15%             | 3%                          |
| I feel my standards grade is an accurate measurement of what I know                   | 18%                      | 64%          | 12%             | 6%                          |

The *End of Semester Student Survey* was administered at the end of the semester grading period (N=33). At the time of the survey 91% of the students understood how their standards grade was calculated, 91% *agreed* or *strongly agreed* that they almost always knew what to improve on, 72% felt that their standards grade accurately reflects what they learned, and 57% were more concerned with their percentage grade than their standards (Table 4).

Table 4  
*End of Semester Student Survey Percent per Question*

| Student Survey Question                                                                                       | 4 –<br>Strongly<br>Agree | 3 –<br>Agree | 2 –<br>Disagree | 1 –<br>Strongly<br>Disagree |
|---------------------------------------------------------------------------------------------------------------|--------------------------|--------------|-----------------|-----------------------------|
| I understand how my standards grade was calculated                                                            | 27%                      | 64%          | 6%              | 3%                          |
| During this semester I almost always knew what I needed to work on/improve                                    | 21%                      | 70%          | 6%              | 3%                          |
| My standards grade reflects what I learned this semester.                                                     | 27%                      | 45%          | 12%             | 15%                         |
| Throughout the semester I was more concerned with my percentage grade than the standards I needed to complete | 27%                      | 30%          | 27%             | 15%                         |

Student survey questions were compared from the three surveys. Student agreement of the importance of a letter grade decreased by 35% during the treatment period. From the *Start of the Year Student Survey* 92% of students indicated that a letter grade was important to them. By the end of the first quarter 82% of students were more concerned with a letter grade than the individual standards. By the *End of Semester Student Survey* 57% of students were more concerned with a letter grade than with the individual standards (Figure 1).

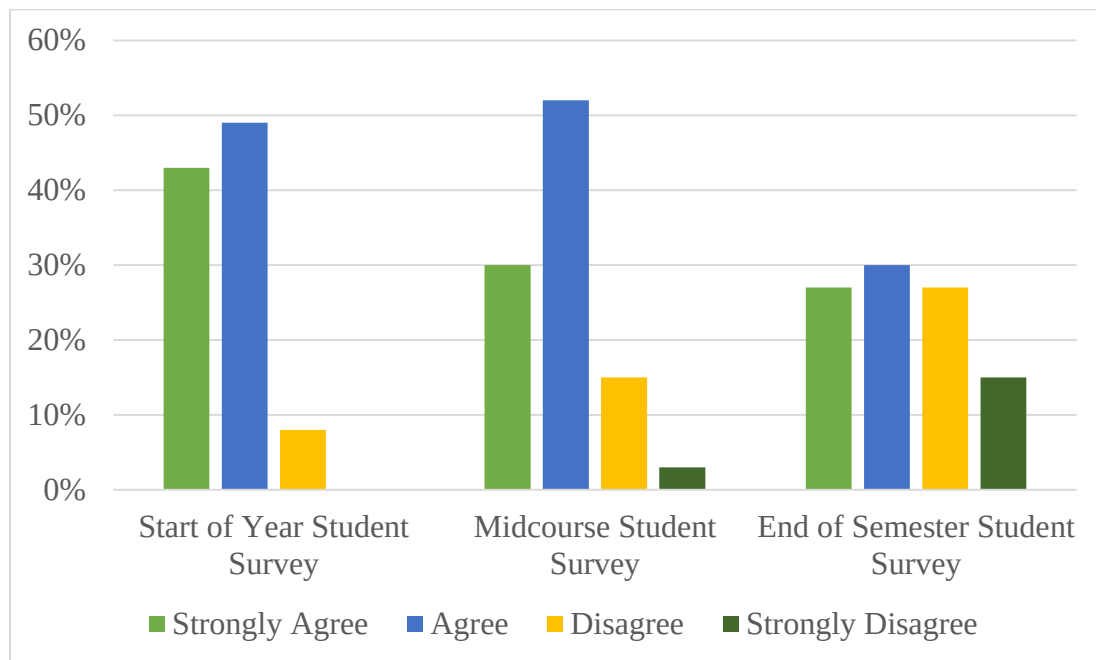


Figure 1. Student survey question – importance of grades.

From the *Start of Year Student Survey* 73% of students were in agreement with the accuracy of the most common grading system. One student wrote, “I like that since most classes use this grading system, it is very easy to understand.” Yet another student wrote, “I like it, but sometimes grades doesn’t mean how much you have learned. You

could have learned a lot, but also have a bad grade.” From the *Midcourse Student Survey* 67% of students had favorable responses to standards-based grading. One student wrote, “I like the standards, it's a unique take on grading, it's a good change from the usual way. Allows you to continuously progress and challenge yourself.” Another student wrote, “I like how relaxed I am, and I also am in charge of my grade.” From the *End of Semester Student Survey* 85% of students agreed that standards-based grading was an accurate way to assess student knowledge. One student wrote, “I like the ability to control my grade a lot more than other classes.” Another student wrote, “I like how the standard based grading gives you the score you deserve.”

Student standards-based grades were analyzed to show overall improvement in knowledge of content ( $N=33$ ). The average normalized gain was 0.44 indicating that 44% of what could have been improved was improved (Figure 2).

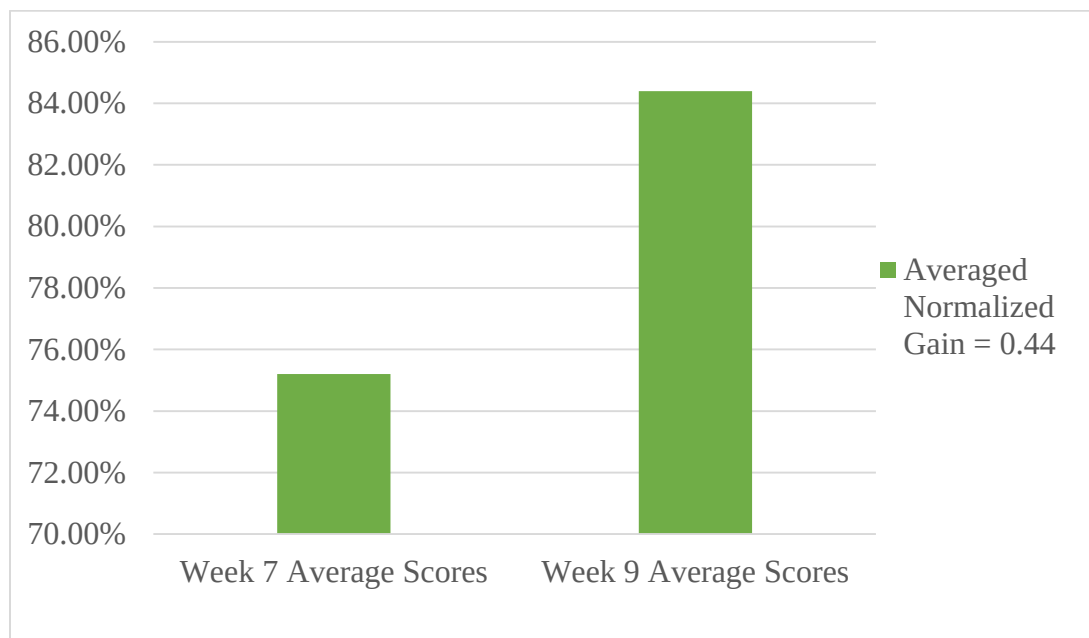
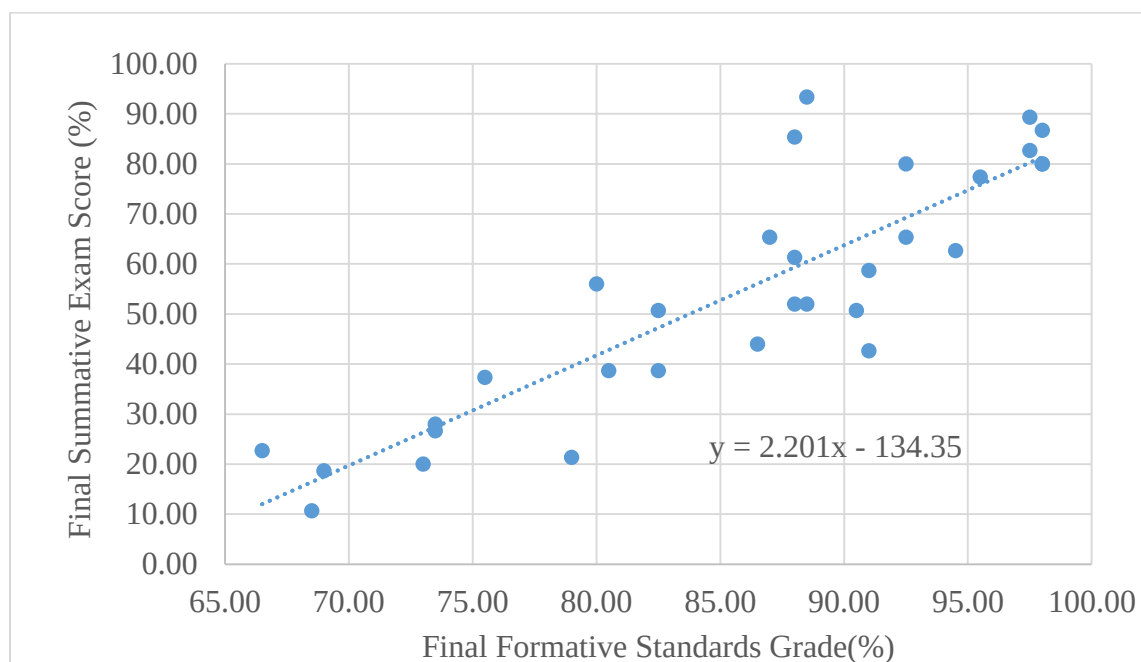


Figure 2. Average scores from weeks seven and nine.

Final student formative standards-based grades were also compared with the end of semester summative final exam score. The formative and summative scores for each student were graphed with a best fit line and equation to show the relationship between how the two assessments correlate to show student learning (Figure 3). Two outliers were removed due to suspicions of cheating during the formative assessments.



*Figure 3.* Relationship between summative and formative physics assessments during the fall semester 2016, (N=31).

Finally, the summative semester final exam scores were compared to the previous two years. The questions on the final exam remained constant over the three school years so that a comparison could be made. A two-sample t-test with a p value of  $<0.1$  was conducted comparing the results from 2014 and 2016. The result showed that within a 90% confidence interval the difference of 9.17% in the mean values between the two years was statistically significant. The data from three years are shown in a box plot. The average scores from the 2014, 2015, and 2016 fall semesters were 42.67%, 46.67%, and

51.33% respectively (Figure 4). These scores were based on the traditional 0-100% grading scale.

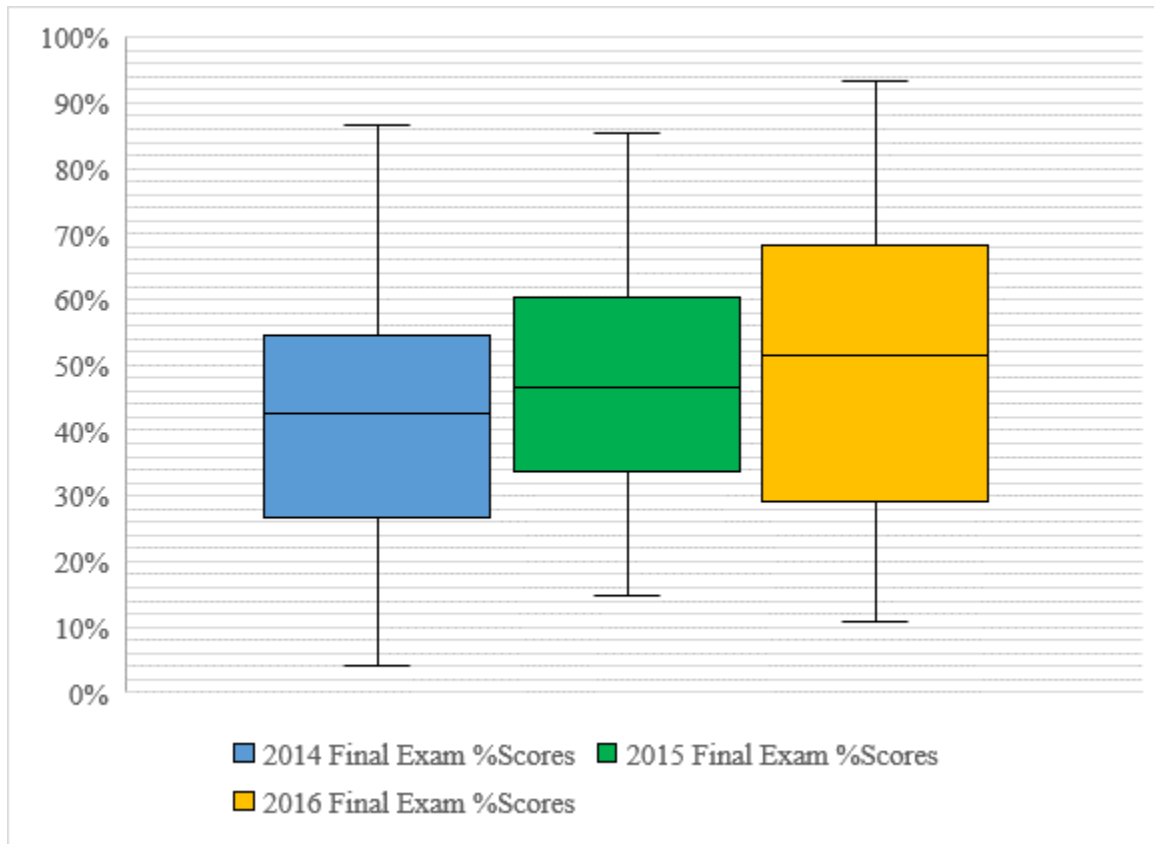


Figure 4. Final exam score trends.

### INTERPERATATION AND CONCLUSION

The main objective of this action research project was to determine if implementing standards-based grading (SBG) had an effect on student performance in a physics classroom. The data comparing student grades from week seven to the end of each quarter showed a medium normalized gain of 0.44 (Figure 2). This shows that for the time during the grading period that students had access to all standards during the final three weeks of each quarter, they were able to show mastery of 44% of

misunderstood concepts. This is different than traditional grading since students do not usually have the opportunity to show mastery of a concept after an examination. The grade they achieve on an exam is the grade they receive for the concept. Also, comparing student achievement on the semester final exam for three consecutive years showed an increase of 9.17% from year one to year three (Figure 4). Lastly, comparing the current final exam scores with the standard-based grade from each student showed a clear linear relationship (Figure 3). With the exception of some outliers, it was possible to predict most student's final exam scores within an error of  $\pm 10\%$  based on their standard-based grade because of the linear relationship. This relationship between the summative final exam grade and the formative standard-based grade shows the effectiveness of utilizing SBG to promote student learning.

The second question was how SGB affects student perception on grading. From the *Start of Year Student Survey* students were asked what they liked about the current, most common grading system including 0-100%, and ABCDF grades. One student responded, "What I like the most about today's grading system is how simple and straight forward it seems, you work hard you will probably get a higher grade and vice versa if you slack off and if you are not doing well and are not too far off it's not too hard to increase your grade." The most interesting part of this response was "you work hard you will probably get a higher grade." If a student works hard they should get a higher grade. At the end of the first quarter students were asked what they liked about the class up to this point. One student commented, "I think the best part of the class is that it is centered around learning...". Another student commented, "I like that the standards give me a

reason to keep trying to learn something even after the first time I failed.” This trend shows some students were realizing that if they complete the standards, they will have a good grade. From the *End of Semester Student Survey* one student commented, “I like how that it is wayyyyyyy different than like normal tests where it's only 1 big test, so that you can be able to fix your grade by SHOWING that you learned by retaking the standards and increasing your grade, to show you have learned and not be stuck with an F if you fail one test at the end of a chapter.” Another student wrote, “If you complete [the standards], your quarter grade can heavily improve.” At this point students are starting to understand that their grade is directly tied to how much they learn. When asked what they did not like about SBG one student wrote, “The one thing I don't like about standards based grading is that your grade never really stays the same.” Another student commented, “The time that it takes to bring your grade up.” No student started with a grade higher than a C, or 75% after taking the first standard-based assessment. This means that students will not be able to achieve an A, or 90% until near the end of each quarter. This was problematic at the beginning. Students would not see a substantial grade increase in the early part of the treatment period which made them feel like they were not learning. From the *Midcourse Student Survey* one student wrote, “I don't like the way your grade is very low to start the quarter.” Even though the grades were not static and they started low, students were able to see the value of starting with an average, or C, grade after assessing the first level of a standard and work their way up to a grade that they wanted for the class. Another student wrote, “I like how relaxed I am, and I also am in charge of my grade.”

## VALUE

This action research-based classroom project was a welcome addition to my classroom. Instituting a system like standards-based grading was an excellent fit to my modeling approach to teaching. Authentically assessing student knowledge should not be done with a system that does not allow students to show growth. Each student learns differently, and at a different pace. What I have found was that students, when given the chance, truly want to learn and will work hard to understand the concepts I want them to learn. For some students, this understanding may take a week, and for others it may take multiple weeks. By the end of a grading period if each student learns the same material they should achieve the same grade.

While using standard-based grading as an assessment platform in my classroom was successful, I would like to restructure how I track weekly scores on the assessments. Currently I do not have a way to track exactly what misunderstandings the students had on a weekly basis. This information is over-written each week when students reassess standards. From the current information, I know what each student mastered and what they struggled with, but I do not know how they progressed through each standard. For instance, I do not know how many times a particular student attempted a specific level of standard. I do not have data that shows information about each question that I ask students to answer. There may be an issue with a particular question rather than with the concept. The information I have gained will help my instruction in future years by showing what topics students struggled with so I can accurately plan broad topics, but I

do not have specific information about each concept that would help me drive daily instruction.

Finally, during the treatment period of the project my total class enrollment was much smaller than previous years. This may have inadvertently skewed my data by not having a large enough sample size to compare to previous years. I plan to continue using standards-based grading during future school years and to collect data. I will then be able to compile a larger sample size which will allow me to better understand the effectiveness of standards-based grading.

Overall the action research process was a productive one for me as a teacher, both in how I teach and how I assess students. Through the process of implementing standards-based grading I have gained a new appreciation of the different learning styles and levels of students. I was able to identify struggling students much more quickly by using weekly formative assessments that challenge students, but which were not detrimental to their final grade in my class. I could better structure the flow of my class, spend more time on topics that students struggled with, and spend less time on those that they grasped quickly. Utilizing standards-based grading also gave me the opportunity to self-analyze my own knowledge of the subject I teach, and determine whether my methods were effective or not. If what I taught did not align with what I assess, the lesson needed to be fixed or replaced. Finally, the feedback I received from my students gave me insight into what they were thinking and how they were learning. This gave me another opportunity of self-reflection into my own teaching methods.

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## APPENDICES

APPENDIX A  
IRB EXEMPTION FORM



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

960 Technology Blvd. Room 127  
 c/o Microbiology & Immunology  
 Montana State University  
 Bozeman, MT 59718  
 Telephone: 406-994-6783  
 FAX: 406-994-4303  
 E-mail: cherylj@montana.edu

*Chair:* Mark Quinn  
 406-994-4707  
 mquinn@montana.edu  
*Administrator:*  
 Cheryl Johnson  
 406-994-4706  
 cherylj@montana.edu

**MEMORANDUM**

**TO:** Erik Tietzen and John Graves

**FROM:** Mark Quinn *Mark Quinn CJ*

**DATE:** August 29, 2016

**RE:** "Utilizing Standards Based Grading as a Formative Assessment in a High School Physics Classroom"  
 [ET082916-EX]

The above research, described in your submission of **August 29, 2016**, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

START OF YEAR STUDENT SURVEY



## Start of Year Student Survey

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. As such, please be as honest as possible. No personal information will be gathered.

|                                                                               | Strongly Agree | Agree | Disagree | Strongly Disagree |
|-------------------------------------------------------------------------------|----------------|-------|----------|-------------------|
| Information about how hard I tried in class is important to me                |                |       |          |                   |
| My teachers let me know how well I'm doing throughout the year                |                |       |          |                   |
| My score on tests matches how well I've learned in class                      |                |       |          |                   |
| My teachers make clear what I'm supposed to learn                             |                |       |          |                   |
| My grade for a class matches what I've learned in that class                  |                |       |          |                   |
| I understand how assignments and tests are used to figure my grade in class   |                |       |          |                   |
| I can learn everything my teachers are teaching                               |                |       |          |                   |
| A letter grade for a class is important to me                                 |                |       |          |                   |
| A list of the standards to be learned in a class would be valuable            |                |       |          |                   |
| A score to show how well I've learned each idea is important to me            |                |       |          |                   |
| Specific information about how well I've learned this year is important to me |                |       |          |                   |

What do you like most about the current, most common grading system? (0-100%, occasional exams, ABCDF grading scale)

What do you like least about the current, most common grading system? (0-100%, occasional exams, ABCDF grading scale)

This survey was modified from <https://www.surveymonkey.com/r/H73NCS2>

APPENDIX C  
STUDENT INTERVIEW QUESTIONS

\_(Responses recorded by digital video/audio)

1. What is your opinion about grades?
2. How did you like utilizing Standard-Based Grading to show what you know?
3. If you could change anything from last semester, what would it be?

APPENDIX D

MIDCOURSE STUDENT SURVERY



## Midcourse Student Survey

---

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. As such, please be as honest as possible. No personal information will be gathered.

|                                                                                       | Strongly Agree | Agree | Disagree | Strongly Disagree |
|---------------------------------------------------------------------------------------|----------------|-------|----------|-------------------|
| I understand how the Standards Based Grading system works to calculate my grade       |                |       |          |                   |
| I feel my standards grade is an accurate measurement of what I know                   |                |       |          |                   |
| I am more concerned with the percentage grade than I am with the individual standards |                |       |          |                   |

Share your thoughts on the progress of the semester so far. What do you like best?

Share your thoughts on the progress of the semester so far. What do you like least?

APPENDIX E

END OF SEMESTER STUDENT SURVEY



## End of Semester Student Survey

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. As such, please be as honest as possible. No personal information will be gathered.

|                                                                                                | Strongly Agree | Agree | Disagree | Strongly Disagree |
|------------------------------------------------------------------------------------------------|----------------|-------|----------|-------------------|
| My standards grade reflects what I learned this semester                                       |                |       |          |                   |
| During this semester I almost always knew what I needed to work on/improve                     |                |       |          |                   |
| Knowing the standards beforehand helped me organize my learning                                |                |       |          |                   |
| I understand how my standards grade was calculated                                             |                |       |          |                   |
| I feel that I had many opportunities to get help this semester                                 |                |       |          |                   |
| In physics I was more concerned with my grade than knowing which standards I needed to improve |                |       |          |                   |
| I feel prepared for the final exam                                                             |                |       |          |                   |

Now that you have finished a semester of standards based grading, what do you like most about the grading system?

What do you like least about the standards based grading system?

APPENDIX F

FINAL EXAM

### Midterm Exam #1, Part A

**Exam time limit: 50 minutes.** You may use a calculator and both sides of ONE sheet of notes, *handwritten only*. Closed book; no collaboration. Ignore friction and air resistance in all problems, unless told otherwise.

**Part A:** For each question, fill in the letter of the one best answer on your bubble answer sheet.

Physical constants:  $g = 9.80 \text{ m/s}^2$

(2 pts. each) **Convert** the following quantities into the given units:

1.  $430 \text{ km} = \underline{\hspace{2cm}} \text{ cm}$   
 A.  $4.3 \times 10^{-7} \text{ cm}$       D.  $4.3 \times 10^5 \text{ cm}$   
 B.  $4.3 \times 10^{-5} \text{ cm}$       E.  $4.3 \times 10^7 \text{ cm}$   
 C.  $4.3 \times 10^{-3} \text{ cm}$
  
  2.  $3.5 \text{ mm/s} = \underline{\hspace{2cm}} \text{ m/min}$   
 A.  $0.21 \text{ m/min}$       D.  $2.1 \times 10^3 \text{ m/min}$   
 B.  $2.1 \text{ m/min}$       E.  $2.1 \times 10^4 \text{ m/min}$   
 C.  $2.1 \times 10^2 \text{ m/min}$
  
  3.  $7.5 \times 10^{-4} \text{ km}^2 = \underline{\hspace{2cm}} \text{ m}^2$   
 A.  $0.075 \text{ m}^2$       D.  $7.5 \times 10^4 \text{ m}^2$   
 B.  $7.5 \text{ m}^2$       E.  $7.5 \times 10^6 \text{ m}^2$   
 C.  $750 \text{ m}^2$
  
  4. (1 pt.) How many **significant figures** does the value " $4.0050 \times 10^6 \text{ kg}$ " have?  
 A. 2      D. 5  
 B. 3      E. 6  
 C. 4
  
  5. (2 pts.) How many **megabytes** are in one **terabyte**?  
 A.  $10^3$       D.  $10^{12}$   
 B.  $10^6$       E.  $10^{15}$   
 C.  $10^9$
-

A 110-kg basketball player can jump a vertical distance of 1.3 meters (approx. 4 feet). For this entire problem, assume that the athlete has NO horizontal motion. (Ignore air resistance.)

6. (2 pts.) What must be the player's **initial vertical velocity** as he leaves the ground?

- A. 3.4 m/s
- B. 5.0 m/s
- C. 7.6 m/s
- D. 9.2 m/s
- E. 11 m/s

7. (1 pt.) At the moment the athlete reaches his maximum height, which of the following is/are equal to **zero**?

- A. his velocity
- B. his speed
- C. his acceleration
- D. A & B only
- E. all of the above

8. (2 pts.) How much **total time** elapses during his *entire* jump, from take-off to landing?

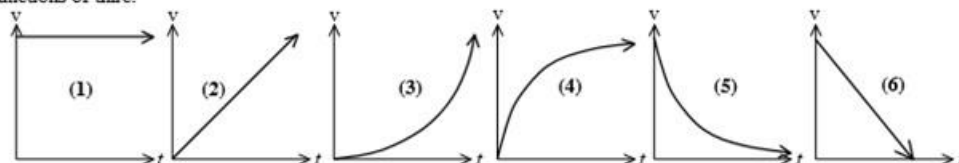
- A. 0.78 s
- B. 1.0 s
- C. 1.3 s
- D. 1.6 s
- E. 1.9 s

9. (1 pt.) Suppose that a smaller, 75-kg athlete jumps with the *same initial velocity* as the 110.-kg athlete does.

Which one of the following is **TRUE**?

- A. The 75-kg athlete will reach a greater maximum height.
- B. The 75-kg athlete will reach a lower maximum height.
- C. The 75-kg athlete will be in the air for a longer period of time before landing.
- D. The 75-kg athlete will be in the air for a shorter period of time before landing.
- E. None of the above.

Six different cars move along one-dimensional tracks. The following six graphs represent their **VELOCITIES** as functions of time:



10. (1 pt.) Which of the above car(s) has a **constant speed**?

- A. (1) only
- B. (2) only
- C. (6) only
- D. (2) & (6) only
- E. (1), (2) & (6)

11. (1 pt.) Which of the above car(s) has a **constant negative acceleration**?

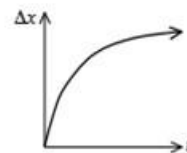
- A. (4) only
- B. (5) only
- C. (6) only
- D. (5) & (6) only
- E. (4), (5) & (6)

12. (1 pt.) Which of the above car(s) is **slowing down**?

- A. (4) only
- B. (5) only
- C. (6) only
- D. (5) & (6) only
- E. (4), (5) & (6)

13. (2 pts.) Which of the above car(s) has a **displacement graph** roughly like this one:

- A. (4) only
- B. (5) only
- C. (6) only
- D. (5) & (6) only
- E. (4), (5) & (6)



14. An object slides down a stationary ramp. The kinetic friction force on the object...
- always points perpendicular to the surface of contact
  - always points opposite to the direction of the object's velocity
  - has a magnitude that is proportional to the speed of the object
  - has a magnitude that is proportional to the acceleration of the object
15. In order for you to push a big 130-kg wooden crate along a level concrete floor at a constant speed, you find that you must apply a constant horizontal force of 700 N to the crate. What is the coefficient of kinetic friction between the crate and the floor?
- 0.48
  - 0.55
  - 0.62
  - 0.70
  - 0.77
16. Which one of the following is NOT one of the 4 Fundamental Forces of physics?
- Electromagnetism
  - Gravitation
  - Newtonian Force
  - Nuclear Strong Force
17. Suppose that a 225-kg bobsled in last month's Winter Olympics starts a downhill run with an initial speed of 8.00 m/s. The sled descends a 45.0-meter-high hillside which has angle of 30 degrees. Without friction or air resistance, calculate the bobsled's final speed at the bottom of the hill:
- 21.0m/s
  - 22.5m/s
  - 30.8m/s
  - 38.2m/s
18. Now, suppose in real life that friction is present. The same bobsled starts with the same initial speed and descends the same hill as in #17, but its actual final speed at the bottom of the hill is only 24.0 m/s. Calculate the coefficient of friction  $\mu_k$ .
- 0.08
  - 0.21
  - 0.35
  - 0.42
19. A block of mass  $m$  is being pushed on a horizontal surface. The coefficient of friction between the block and the surface is  $\mu_k$ . A person pushes on the block with a horizontal force  $F_p$  in an attempt to keep it moving at a constant velocity. What is the minimum magnitude of  $F_p$  needed for the block to keep sliding?
- $mg \cdot \mu_k$
  - $(mg) / \mu_k$
  - $(F_p + mg) \cdot \mu_k$
  - $F_k / \mu_k$



20. You are in an elevator in a tall building when the elevator cable suddenly snaps. As a physics student, your horror is immediately eclipsed by your realization that you are in freefall. As you study the situation, you realize which one of the following is TRUE?
- Your acceleration is zero.
  - Your weight is zero.
  - The sum of all forces acting on you is zero.
  - If you were to stand on a bathroom scale, its reading would be zero.
-

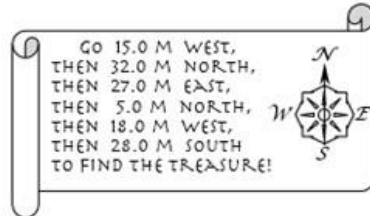
### Midterm Exam #1, Part B

**Part B:** Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. For any multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).

1. While doing a treasure hunt with a team of your friends, you receive the instructions shown at right:

a. (8 pts.) Instead of measuring out and walking along each individual segment, you convince your friends that it is faster to add together the six displacement vectors to find their sum, and then go directly to the end! Find the **magnitude** and **direction** of the **net (total) displacement** that you should travel from your starting point. *Show your work, and explain any shortcuts.*

*Note:* You are welcome to use compass directions in your final answer, but express your final direction explicitly and clearly. *Examples:* "30.0° to the E of N," or "60.0° to the N of E."



b. (6 pts.) Suppose that a different team doing the same treasure hunt does not know how to add vectors, so they traverse all of the separate path segments as given in the clue, eventually arriving at the treasure 15.0 minutes later. Find the magnitudes of this team's **average speed** and **average velocity**, both in [m/s]. *Show your work.*



2. A cannon at the top of a cliff always fires cannonballs with an initial velocity of  $60.0 \text{ m/s}$ . Two identical cannonballs are fired at different initial angles (ignoring air resistance):

Cannonball A is fired at  $20.0^\circ$  above the horizontal, and takes  $7.56 \text{ s}$  to land.

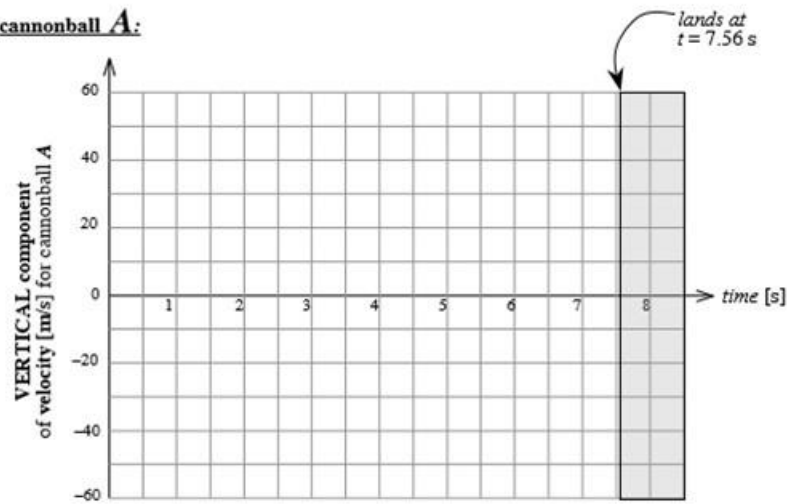
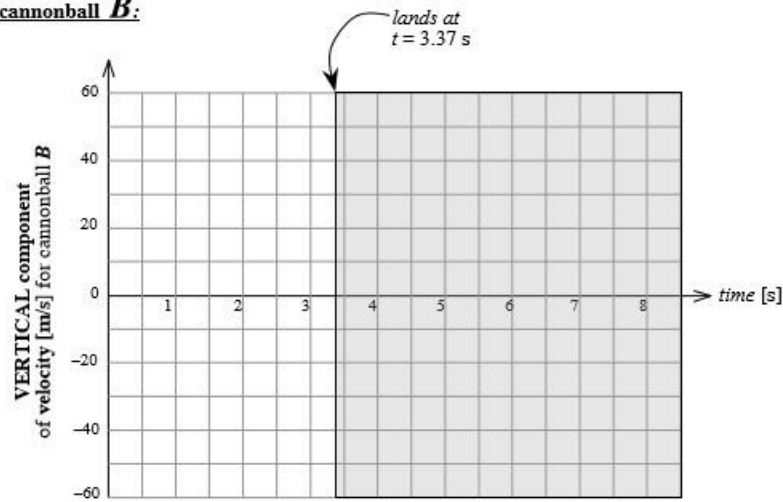
Cannonball B is fired at  $20.0^\circ$  below the horizontal, and takes  $3.37 \text{ s}$  to land.

a. (6 pts.) Decompose BOTH cannonballs' initial velocities,  $\mathbf{v}_{A0}$  and  $\mathbf{v}_{B0}$ , into their **x- and y-components**. Finish by writing out both  $\mathbf{v}_{A0}$  and  $\mathbf{v}_{B0}$  in component notation. *Show your work clearly, and explain any shortcuts.*

b. (4 pts.) Using the information for *either* cannonball A or B (you don't need both), find the **height  $H$**  of the cliff. *Show your work.*

2. continued:

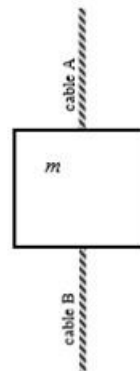
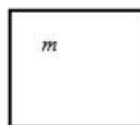
c. (6 pts.) On the axes provided, *carefully and accurately* graph the **VERTICAL component** of each cannonball's **velocity** versus time, from launch to landing. (You do *NOT* need to show any calculations for this part. *Hint:* For each cannonball, find and plot the *initial* and *final* velocities, then connect them with the appropriate mathematical curve.)

cannonball A:cannonball B:

**Part B:** Show your work on all free-response questions. Be sure to use **proper units** and **significant figures** in your final answers. For any multiple-choice questions, circle the letter of the one best answer (unless more than one answer is asked for).

1. A large, heavy crate ( $m = 250.0 \text{ kg}$ ) is suspended on cable A from a crane. At all times, a worker pulls downward on cable B with a constant  $380. \text{ N}$  of force, to help guide and steady the crate. Both cables are exactly vertical. Assume that both cables are massless and inelastic.

a. (2 pts.) Using the crate shown at right, create a **free-body diagram** of  $m$ , showing **ALL** forces acting on it. **LABEL** ALL force vectors with names. (You do NOT need to calculate their magnitudes for this diagram.)



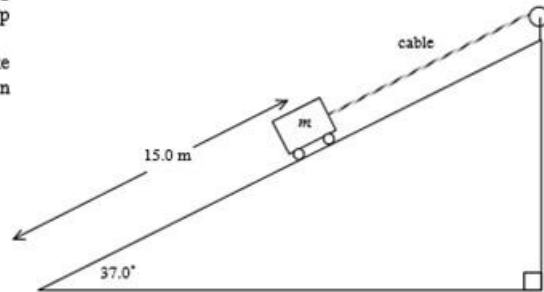
b. (2 pts.) If the crate is *at rest*, the **magnitude** of the **tension** in

**cable A** is: \_\_\_\_\_

You do NOT need to show your work for part (b).

c. (5 pts.) Later, while the crate is moving, the tension in cable A is measured to be  $2750. \text{ N}$ . (The worker is still applying  $380. \text{ N}$  of downward force on cable B.) Find the **magnitude** and **direction** of the crate's **acceleration**. Show your work completely.

2. While being loaded onto a cargo ship, a 925-kg crate on *frictionless* wheels is pulled up a  $37.0^\circ$  ramp by a cable. The crate is presently at rest.
- a. (3 pts.) On the free-body diagram of the crate below, **draw and name all force vectors** acting on the crate:



- b. (6 pts.) Calculate the magnitude of the **force of tension** in the cable while the crate is at rest. Show your work.
- c. (1 pt.) If, instead of being at rest, the crate were being pulled uphill at *constant speed*, your **answer to part (b)** would become:
- A. greater                      B. less                      C. unchanged
- d. (6 pts.) The crate is at rest, 15.0 meters along the ramp. If the cable suddenly breaks and the crate rolls down frictionlessly, what will be its **final speed** at the bottom of the ramp? (You may solve this either using conservation of energy, or using force and kinematics. In either case, show all steps in your work.)

Test modified from

<http://www.phys.hawaii.edu/~nassir/phys151/examanswers.html>