Improving Depth of Student Understanding of Physics Content Using Standards Based Grading

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IMPROVING DEPTH OF STUDENT UNDERSTANDING OF PHYSICS CONTENT USING STANDARDS BASED GRADING

State University of New York College at Brockport
A project submitted to the Department of Education and Human Development of the State University of New York College at Brockport in partial fulfillment of the requirements for the degree of Master of Science in Education

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Improving Depth of Student Understanding of Physics Content Using Standards Based Grading

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Chapter 1: Introduction

Problem Statement

Teacher education programs tend to, of course, heavily favor teaching methods useful for within the classroom, classroom management, best practices, etc. However due to a recent study by Jennifer Randall (2010), it appears that more focus and teacher educational programs should be given to the grading practices of teachers.

Much of the research in education shows that grading and reporting are foundational elements in every educational system, but the key to keeping the system healthy is making the grades meaningful. Guskey (2015) performed a study noting various research sources on grading methods and synthesizing these sources into a number of conclusions when it comes to grading. Through this process, this study established multiple qualities necessary for effective grading methods based on the most current and up-to-date research studies. The first step in sound classroom assessment practices is to ensure that the grades are meaningful.

Significance of the Problem

Though grades are used for college admittance, high school graduation, levels of honors, etc. the value that represents the grade itself is just an arbitrary number. A person sees a student's particular grade in a science class, for example, and assumes that the student has an understanding of science, when in actuality, that student could have done very poorly on each assessment but may have been an excellent participant in class discussions and added to class culture. The point of standardized grading is to use grades as a tool help students, teachers, parents to understand what it is the students is strong in and what it is they should be working towards. Students often have no idea where their grade comes from. They see numbers go in they see a calculation and a grade appears as a result. Standardized grading proposes to take the mystery away from the grade,
so that students can have power over improving the grade, if they so choose, in dissecting their understanding of various topics.

Purpose

To be useful, grades must be accurate reports of evidence of students' performance against standards. When grades are calculated arbitrarily and have no meaning to students as to how they arrived at the grade they have, we as educators are missing out on a valuable tool for education. Grades should be used as a communication mode to students, teachers, and parents communicating what content the student knows and what content they still need to master. The student is empowered to understand how to increase their score and knows the information that will be more important for them to understand. As a result, learning is differentiated for each student who can become aware of how to learn what they do not understand simply by inspecting their standards based grades

Rationale

Rather than a student receiving an 80% on a quiz, that student would be able to say “I did great on each part of math except I really need to work on adding fractions”. In this way, students of every age can work to get better because they understand the magic behind calculating the value of their grade. Separate grades could still be given for the student's ability to turn in assignments on time, provide effort in class, or participate in classroom discussions. Thus, when a person looks a student's report card, they can say John has a b level understanding of the content associated with chemistry, meaning John has mastered roughly 85% of the course material. Colleges and universities look at grades as information that a student successfully completed and deeply
understand some knowledge of a course. It is important for these grades to reflect what students actually know.

Furthermore, this can benefit the level of instructional teaching. Students have a clear understanding of where the course is going and what content they are expected to know to be successful. Standardized grading requires a teacher to lay out the standards, in simple terms for students, prior to diving into a topic. Additionally, students will be able to receive multiple grades back on a test, one score per standard. This allows student to see where they struggled and where they were successful. Beyond allowing the students to recognize where they have not been successful, standardized grades allows for the student to take a retake assignment to show that they have mastered the content. To receive a perfect hundred percent in the course would require a student to be 100% accurate and mastered in every one of content standards and to approve that in some way.

One of the major future benefits of mastery grading is the ability for students to have a clear understanding of how they would be evaluated in the professional and post-secondary world. Parents note that standards-based grading is similar to workplace evaluations. For example, in a doctoral degree program students are given milestones that need to be reached by the end of the semester. At the conclusion, they write a reflection linking activities after each competency. A practice in mastering grading allows students to be better prepared for how true assessments in the workplace function (Shippy, 2013).

Definition

**Standards Based Grading:** A system of reporting student proficiency in a number of specific learning targets (or standards). Rather than give students one grade on a test that
assessed multiple skills, this system gives students a number of scores that represent their proficiency in each of the skills assessed. The result is a focus on knowledge, not on points.

Summary

Pollio (2016) reports on the success of implementing a basic standards based grading system in 11 urban high schools in Kentucky. Though he still continued to have the same number of conversations with teachers, students, and parents concerning student grades, the conversations veered away from the typical grievances- complaints over a couple of percentage points, begging for bonus, etc. The new conversations about grades centered on student understanding and misunderstandings. Conversations about bringing up grades focused on students’ access to additional learning opportunities and reassessments for concepts that they had previously missed. Furthermore, Pollio (2016) found that students knowing and understanding what their grade actually represents motivated students. Additionally, switching the grading system increased standardized test grades within a year! Finally, standard based grading in this study helped economically disadvantaged students as well as minorities to close the learning gap on standardized tests. If educators can move from having meaningless conversations about random numbers assigned to students as their grades to heaven meaningful conversations with students and families about misconceptions and remaster assignments, imagine what successes could follow.

Grades, when assigned based on achievement enable teachers to compare knowledge and skills of current and previous students. Additionally, grades allow teachers to accurately determine the preparedness of incoming students and the students they are sending to the next
level. This would also provide parents and students with a clear picture of their knowledge and understanding of the content of the course at hand (Jennifer Randall, 2010).

Chapter 2: Literature Review

Contemporary Issues/Trends in Science Education
Innovations in Instruction

Tlili (2016) considered the relationships between personality and student success in a computer-based learning environment. Currently, one of the main concerns of computer-based learning in the classroom is how to match and conform the styles to each student's learning differences. Tlili (2016) synthesized information from many other studies to arrive at conclusions relating to computer-based learning. The topics of synthesized studies included the study of common personality tests, how personality traits have been shown to affect learning, the effect of personality on a students’ approach to collecting information, communicating, peer interactions, and behavior. In addition to personality information, the study also synthesized data pertaining to the various ways that computer based learning can take all interest and angles into account, and traditional ways of identifying personalities of people.

This study first found the difference between different personality models in terms of their unique effects on computer-based learning. Among the methods included were the Myers-Briggs personality type indicators, the Big Five Factors, and Hans Eysenck’s model. Using these common, well accepted personality indicators the study showed how differences in learners’ personalities affect computer-based learning. First, the study established the Myers-Briggs personality type indicator as the most referred to personality model and computer-based learning, as 14 of 19 studies used it as the model to determine the learner’s personality. This method was followed by the Big Five factor used in 4 of 19 studies. The implication of the knowledge gained
from each computer assessment is of value personality tests of validity of using the certain personality type indicators for the computer system to assess the Learners personality type.

Additionally, Tlili (2016) showed that the learner’s personality does have an effect on the behavior of the learner. Learners recollected information more easily with a particular type of design parameter based on their personality. Similarly, subjects benefited from personalized user interfaces based on their personality as well as an interface model that was synchronous or asynchronous and followed the learning style for groups or independently. These three significant effects of personality on computer-based learning are among a list of 18 found by the research. This strongly supports the study of further functionalities for learners to be available throughout the computer-based learning process. While new computer systems are being developed creators, researchers and educators, should consider elements of personality in their systems.

One of the weaknesses of this study is simply the fact that since computer based learning is so new, not much is known about the long term effects of computer based learning on student personalities and further research is needed to validate the connection between personality type and effectiveness of computer learning. Additionally, this study was solely based on a literature review and not on empirical study. The conclusions presented in this lab focus around synthesized information from various sources of literature but is limited by the literature found and the lack of the study’s own experimental evidence.

The synthesized literature search completed by Tlili (2016) study found four significant conclusions. First, personality is strongly linked to how well a learner learns, communicates with others, recalls information, solves problems, takes notes, etc. Secondly, many personality variables were established that researchers should consider when looking to provide an adaptive
computer-based learning system. The variables can be within the learner themselves or within
the given learning system, such as interface design, provided learning strategies, etc. Third, the
Myers-Briggs model is the most referred to model in literature at 74% percent (based on this
study) and is most useful of personality models in identifying the learner’s personality. Finally, a
new approach for computer-based learning systems that refers to implicit methods using learning
analytics instead of questionnaire-based approaches was suggested. The purpose of these implicit
methods is to provide an adaptive computer-based learning process based on the learner's
personality.

The implications of this study or any computer-based learning study are so significant
because there is a lot of potential power and the use of computers for learning. Computers can
give timely and explicit feedback to the learner as well as record and trace their progress more
easily than other classroom tools. Computerized learning tools can also differentiate the teaching
and learning process to fit the learner's needs. However, it would be helpful to understand the
learner’s personality so that the computer could make the right changes to the programs.
Furthermore, some personalities need extra tools and support to be successful in a computer-
based learning environment.

The study noted that individual’s real-world actions, taste and behaviors are found to be
significantly connected to their personalities, from which people make professional judgments
and decisions. Thus, different learners require different responses to educational methods based
on the personality and it is important to match the learner with the correct technique. For
example, a designed educational game is adapted based on the obtained personality results of
each learner, knowing that an extrovert typically enjoyed risks more than an introvert. An
educational game on a computer may send an extrovert on a game path were various game
enemies are implemented whereas an introvert learner playing the same game would be redirected to safe game paths. Furthermore, collaborative learning opportunities could be personalized based on personality, with learners being assigned to groups with the same or opposite personalities as them depending on the needs of the activity (Tlili, 2016).

A study conducted by Colby Tofel-Grehl (2017) sought to show the differences in engagement and attitude for students who are studying electricity through electronic textiles in contrast to those studying circuits traditionally. The electric textiles (also known as “sewable circuits”) were introduced into 8th grade science classes with the intent of exploring possible gains in student learning and motivation, particularly for underrepresented minorities. Of the students studied, four classes engaged in traditional circuitry throughout the unit while four other classes studied a new electric textile unit. Overall, this study showed that both groups experienced significant learning gains on standard items without significant differences. However, significant differences did appear between the groups attitudes towards science. Those that studied electricity through the textile unit showed an increasing interest in science over those who studied traditionally.

The motivation for the study, and largely the study of increasing young people's interest in science, specifically women and underrepresented minorities, arose from the fact that there is a 7% increase predicted in STEM careers by 2018. However, only 16% of US undergraduates are studying STEM careers and women and historically underrepresented racial minorities are still remaining out of the STEM field. In addition, many studies have blamed this lack of representation on an “Identity Gap”, where these groups struggle to see themselves as successful in a STEM field. However, the middle and high school years are the critical years when students are most likely to alter their interest and confidence in science drastically. Studies largely show
that participating in inquiry-based Hands-On science learning activities largely increases middle school students interest in pursuing science or engineering is a future career.

This study seeks to add to the conversation by addressing this need using an experimental design to compare motivation, identity, and learning outcomes associated with changing approaches to the study of electricity in 8th grade science classrooms. Colby Tofel-Grehl (2017) completed this study through the use of what are known as electronic textiles Electronic Textiles refer to electronic components such as LED lights, batteries, microcontrollers, etc. that are sewn together using conductive thread and then programmed. This creates an electric circuit and becomes a sort of craft based project for students. This approach seeks to give students an inquiry and design based learning pathway, which has been shown to foster student science interest by engaging students in projects and using those projects to understand the value and relevance of engineering design and scientific thinking, thus allowing students to embed science content into their everyday thinking and experiences, and link science to real events.

155 students participated in the study, all of which were in eighth grade and enrolled at mountain high middle School, a diverse middle School in the west mountain region of the US. The data collected focused on students’ identity beliefs and motivation after the unit on electricity through surveys, observation, and interviews.

Student responses showed significant results for responses related to teacher, family, and friends. First, with item response is related to teachers, the results uncovered significant differences between the study and control groups pertaining to two specific variables; “My teacher cares if I think science is interesting” and “My teacher cares if I learn science”, with p values p=0.015 and p=0.018 respectively. Relating to family, two questions appeared to be significant between the two groups studied; “It is important for my family that I try my best at
school” and “My family would be happy if I chose to pursue a career in science”, with p values of p=0.023 and p=0.001 respectively. Finally, as it relates to peers, three item responses were shown to be significant; “How many of your close friends like STEM”, “How many of your close friends care about your grades”, and “How many of your close friends encourage you to do well in class” showing p values of p=0.039, p=0.005, and p=0.012 respectively. The p values that are less than p=0.05 show statistically significant results between the two groups while the p values less than p=0.001 show very statistically significant data. In each of these item responses, Colby Tofel-Grehl (2017) showed that using electronic textiles over the traditional circuit board to teach eight grade students circuitry increased student relationships and confidence as it relates to teacher, family, and peers in a statistically significant manner.

Findings suggest that student created a textile designs provided opportunities for students to make connections outside of the classroom and may also shift student perceptions of their teachers beliefs about them more positively within the classroom. Changing the electricity unit to a more Hands-On, inquiry, and less invasive approach did not affect student conceptual understanding and academic success pertaining to the circuit content. However, it did reveal significant implications relating to student confidence in science and ability to relate it outside the classroom. It does not matter if students can be successful as a unit as much as it matters if they can draw conclusions outside of the classroom and choose to pursue a further career in stem. Increasing student engagement thus did not impact their ability to learn the content in the same amount of time. This thus provides implications for future studies looking at increasing student accessibility to materials used to teach science. Providing students with electronic textiles to study circuits provided students the understanding of the content that they needed but also made science more fun, engaging, and applicable to their lives. Increasing student
confidence will thus impact the success they will have in future careers and classes in STEM (Colby Tofel-Grehl, 2017). Future studies should use this as a step toward creating innovative, non-traditional ways to teach science content in the classroom, knowing the significant effect it will have on student attitudes towards science and confidence as well as student attitude adjustments relating to their families, peers, and teachers.

Quantum mechanics is traditionally either taught at the conclusion of a year of physics or is not taught at all. The reason for this is that many physics instructors believe that quantum mechanics is an abstract subject that cannot be learned before classical physics and the math required for solving equations. Dean A. Zollman (2001) strongly believes this to be incorrect, and through a study using instructional materials for quantum mechanics that were more conceptual based in mathematics based, proved that quantum mechanics can be integrated throughout the year of physics.

Dean A. Zollman (2001) created a Hands-On approach to learning for teaching quantum mechanics through a number of materials that can be accessed online. The study included students from approximately 160 different schools with 175 different teachers. Of these groups, the teachers collected data through diagnostic tests and reported the results.

As part of the proposed new curriculum for students to learn quantum mechanics, Dean A. Zollman (2001) made an effort to integrate Hands-On approaches with a paper and pencil method, thus attempting to effectively eliminate any sitting in lectures. The group also set out with the goal to eliminate any need for solving mathematical equations when learning quantum mechanics and rather relied on conceptual based questions and materials that involve quantum mechanics the students may be familiar with. The program's goal was to provide interactive visualizations that physics students could use to conceptualize they're learning. This process
relied on a web-based approach too much of a program, allowing it to be tested by such a vast number of schools and teachers.

The method used is referred to as visual quantum mechanics. The materials were divided into four major and relatively short instructional units with two units for background knowledge. The first unit involved solids and light, where students used LEDs and gas lamps to understand the concepts of specific energy levels, energy bands, transitions, and spectra. For many students this should be review of their chemistry science class. The second topic is luminescence, where students utilize fluorescent and phosphorescent materials to understand the effects of impurities on energy bands. Thirdly was waves of matter, allowing students to explore the creation of a model to explain the wave particle duality of electrons in addition to Schrodinger's equation. All of this was done qualitatively without the use of mathematical equations. The fourth topic involved seeing the very small and referred to quantum tunneling specifically. This fourth topic was used to simulate the scanning tunneling microscope as a vehicle to teach quantum tunneling as well as some of its current applications. Unit 5 was potential energy diagrams where magnets were used along a track with toy carts to review energy conservation and to learn about the various shapes of the potential energy diagrams. Finally the six unit was making Waves, which was also a review on some properties of waves including wave interference and various wave phenomenon.

In addition to relying on Hands-On learning, real life examples, and paper to pencil worksheets, the teacher-student relationship for the success of this curriculum was also shown to be undeniable. In order to have an interactive environment where students are challenged to think outside of the box, students need to respect the teacher's knowledge and the teacher needs to get students to be excited about the topic, as students will be responsible for most of their
learning and the teacher is simply the facilitator. The study was designed for the units to be completed in a classroom with students working in small groups using the equipment that was provided such as LEDs, lamps, light sticks, computer visualizations, etc. The purpose of the short lesson segments is to create a sample size that the teacher can insert into any segment of the class throughout the year. These applications do not need to wait till the end of the school year to be taught, nor do students need any background in physics to understand each of the six tutorials.

All of the tutorials for this quantum mechanics curriculum created by Dean A. Zollman (2001) was a web-based design, including simulations and programs that can be brought into the classroom through the web. This is beneficial not only for allowing teachers to have access to these materials but also to teach teachers may not be as familiar with quantum concepts as they need to teach them effectively. The system allows for teachers to answer survey questions suggesting improvements to the research group as well as to ask conceptual questions that the teacher may be struggling with.

The implications of this study on visual quantum mechanics have shown that successful teaching of abstract concepts to students with limited science and mathematics background can be extremely successful. The modes of success involve focusing on conceptual knowledge and Hands-On student engagement. However, these materials do also work on students who do have stronger science and engineering backgrounds. They work to enhance anyone's conceptual understanding and visualization of quantum mechanics.

For further research into this topic, Dean A. Zollman (2001) should provide specific evidence of the success of their curriculum. Currently, only the survey results provided by the teachers and their feeling of success were cited as evidence. However it would be helpful to see how students do on a diagnostic assessment pertaining to the topic of quantum mechanics. It
would also be beneficial to see a growth chart outlining where students were before and after the teaching of the curriculum.

**Engaging Students**

Recent research has noted that many students learn very little information from traditional lectures. A study by Catherine H. Crouch (2014) used this knowledge and lack of student learning and to launch a new method of instruction with the purpose of engaging students through what should be a ‘lecture-style’ classroom setting. This developed method, referred to as *peer instruction*, was utilized at Harvard University for students in algebra and calculus based physics classes as a replacement of the traditional lecture-style class. Catherine H. Crouch (2014) claims that through this peer-to-peer instruction strategy students are able to get one-on-one attention all at the same time. The secret is through a questioning technique where students are able to answer and ask questions of each other during their college lecture time.

Many teachers find it difficult to nearly impossible to give each student the attention they need in a common classroom. Understandably so, as a common high school classroom may be 25 students, and in college class sizes rise to being in the hundreds. Though it is well accepted that students do not learn as much from a single teacher talking in front of a group (lecture), it is difficult to find a method to engage so many students with only one instructor. Not surprisingly, the majority of student’s site that they learn better and more in smaller learning environments, and thus find lectures to be ineffective. Through the peer instruction technique proposed by Catherine H. Crouch (2014), students are engaged through a question format and allowed to uncover difficulties with material. As a whole, peer instruction engaged students during class through activities that require each student to apply core concepts being presented, and then to explain those concepts to their fellow students. As opposed to asking a few informal questions in
class, which only engages a number of the top students, this method has each student doing their own thinking, asking, and listening throughout a class.

Peer instruction was used as a technique and Harvard University in algebra and calculus based physics classes. It was used over the course of 10 years and student results were analyzed and compared to the years prior to this new type of instruction. Overall, Catherine H. Crouch (2014) found this method to be incredibly successful. Their data at-large indicates a significant increase in student mastery of both conceptual reasoning and quantitative problem solving upon implementation of peer instruction. The group found gains in student understanding to be the greatest when the questioning strategy was used alongside a number of the other strategies listed throughout the study to increase student engagement. Thus, for every element of the peer instruction course that is utilized, student engagement and active participation will increase, in turn causing their conceptual understanding to increase. In addition to collecting their own data at Harvard University, Catherine H. Crouch (2014) also included a survey sent to 100 other instructors at various universities who began using peer instruction. Of the 100 instructors who implemented peer instruction at their respective universities, 70% reported more positive student evaluations than prior to implementation and 93% reported that that as the instructor had a more positive experience.

To increase the effectiveness and applications of the study by Catherine H. Crouch (2014), further research could be conducted at a high school level, in physics and/or other science classes. This would allow for translation of the peer instruction method into the high school and even middle school settings. Further research into how to complete this method effectively in a high school class, what would stay the same and what would need to change to adopt for high school, would need to be completed. However, since it is clear that students at any
age learn better from active engagement than through lecture style, it would seem reasonable to take the findings of this study and adapt them for lower grades.

Catherine H. Crouch (2014) claims that concept tests, questions designed to expose student difficulties with material and give students a chance to explore, are the cornerstone of teaching with peer instruction. The group proposes a number of physics concept tests on topics such as forces to help uncover student misconceptions and allow students to arrive at a depth of understanding. Furthermore, writing is required for strong peer instruction, to allow students to think and explain. The vast array of multiple choice questions, specifically on explore challenges (like labs, etc.) should be replaced with questions that require students to think and apply. A third method proposed for classroom use to increase student engagement is polling of students. Polling can include a show of hands, holding up flashcards, scanning forms, etc. One of the most difficult practices suggested by Catherine H. Crouch (2014) is the need to change students’ habits, from figuring out what they do not know about a topic after class, or even worse before the test, to getting ahead on the reading before they arrive in class. Reading prior to class allows students to have necessary background knowledge helpful for the engaging activities, thus inspiring more engaging discussions. This will in turn increase the level of rigor and effectiveness of classroom peer instruction. Finally, it should be noted that in order to have the value for your students, Catherine H. Crouch (2014) found a teacher must motivate students from the start of the course and be conscientious of student attitudes throughout instruction. Peer instruction requires students to be significantly more actively involved in instruction then lecture-style, but without student attitudes on board, it will be very difficult to accomplish much of anything.
Over the years studies coming out of physics education research have demonstrated many evidence-based and instructional strategies to enhance conceptual learning of students in introductory physics courses. Typically, the strategies have been tested using assessments that determined students’ conceptual understanding. A study conducted by Joshua Von Korff (2016) performed a review and analysis of the results from two of these commonly used assessments, the Force Concept Inventory and the Force and Motion Conceptual Evaluation. The group evaluated any data published between 1995 and 2014 to complete their own evidence based research.

Through research, Joshua Von Korff (2016) confirmed much of the previous conclusions, for example, they found the interactive engagement teaching techniques are significantly more likely to produce high student learning gains than traditional lecture based instruction. This has been well accepted and was confirmed again by this study. However, further data analysis provided implications that would suggest the interactive engagement instruction works in many settings, includes students with both the high and low level of prior knowledge, is successful at various universities, and in various class sizes.

To complete this test, multiple choice conceptual assessments were used, including dozens of physics topics. While open-ended assessments provide deeper insight into the details of student understanding, well-constructed multiple-choice assessments are easier to grade consistently among a vast research base. Additionally, a good concept assessment can quickly help teachers determine common student misconceptions. The Force Concept Inventory and the Force and Motion Conceptual Evaluation, the two specific concept tests used in this study, were taken by over 50,000 students across many colleges and universities both within and out of the United States between the years of 1992 and 2014. From the papers that evaluated student results
of these tests, Joshua Von Korff (2016) collected information about teaching methods, class sizes, and student performance. This data was input into an enriched database system that categorized the gathered information more thoroughly and exactly than could have been done before. The system was able to determine the type of University, the size of each class, the average SAT scores at the institution, etc. The group used individual classes as a unit of analysis because this was the smallest unit of analysis and the teaching method within a class is generally the same.

Along with showing the interactive engagement had significantly higher learning gains than those in traditional lecture, the teacher noticed a significant variation in the gains within this data, suggesting that there were more factors at play. For data analysis, the study showed that the gains were not correlated with pre-test scores, suggesting that game is a good measure for differentiating between teaching methods and is independent of the initial preparation of students. The correlation between class average pre test scores and normalized gain was $p=0.47$. Additionally, the data shows that small class sizes did not lead to more effective instruction, contrary to what is often suggested. When comparing the effect of class size on student gains, there was no correlation ($p>0.2$). Furthermore, Joshua Von Korff (2016) demonstrated that SAT score and type of institution had no significant effect on student learning gains.

Thus, the data implies that very little affected student gain besides the type of instruction, with interactive engagement instruction creating much greater learning gains on the concept tests given to students than traditional lecture instruction. It also confirms that the gain is a powerful tool for measuring the benefits of interactive engagement instruction. Furthermore, this method can be used to compare courses taught in a variety of contexts, because the context does not seem to affect the amount of gain.
This was a unique study, having been conducted on data collected for over 20 years previous to the study. The limitation may be that some methods have changed over these years or that data was not collected consistently throughout all 20 years in the various contexts. Along the same lines, researchers may report their gains selectively. For example, if they saw gains that were below a certain value, a researcher or teacher may choose not to report that gain, suggesting that the data may be slightly skewed. Further research would need to be conducted but the same concept test to determine if it's delayed a factor.

The nature of the study completed by Cetin (2014) sought to explore the effect of integrating cartoons into a science and technology course curriculum on students’ attitudes and achievement. In short, 64 students were studied in a public elementary school, all of which had statistically similar attitudes and achievement (p=.61 and p=.81 respectively, showing that the differences were not at all statistically significant) towards science. All students heard the same lesson by the same teacher and then were randomly divided into two groups of 32. Half of the students then received curriculum enriched with cartoons. At the conclusion of the unit, a posttest was conducted to evaluate their achievement and attitudes to the science unit on body systems.

The posttest revealed a statistically significant difference in scores for the experimental and control groups compared to their pretest scores, both in terms of student achievement (p<.05) and attitudes (p<.05), signifying statistically significant values. This shows all students gained a significant amount of knowledge and interest in science through the lesson. More significantly however, is the statistically significant results comparing the attitudes and achievement of students in the control group on the posttest with those in the experimental group (p<.05). This data shows that the use of cartoons in science, as a supplemental material, not only gives students
a deeper understanding conceptual understanding of the topic in science but also a deeper interest in studying science. This is an exciting bit of data for sure! Using cartoons in class statistically improved the 32 students’ attitudes in the experimental group to science (Cetin, et al. 2014).

This seems logical that a claim can be made that cartoon-enriched education is more effective due to the increased attainment of scores on the post test. Students’ scores on the posttest increased significantly for both attitude and achievement for those that added the cartoons to enrich curriculum. While all students were able to improve in attitude and achievement, the experimental group’s improvements were statistically higher (p<.05).

If this study were to be completed again to increase validity of results, two conditions could arguably be altered. First, an increased sample set will increase the validity of the results of the study. More students should be added to the 64 currently in the study. Additionally, it would be beneficial for this study, with pretests, posttests, lessons and cartoons woven in, to be conducted by that teacher over multiple units in the classroom. To see that cartoons enrich student attitudes and achievement in science over various units, even in the same context of an elementary school science classroom, would be beneficial.

An implication of this study by Cetin et al. (2014) is the statistical significance of bringing cartoons into the science classroom. This furthers the idea of teaching students where they are to make school engaging. It is understood that kids love cartoons, so bringing something they enjoy and identify with into the classroom is automatically going to increase student interest. Furthermore, if they are interested and more engaged, students will likely learn more and retain the information. It is possible that it is easier for students to remember the information and understand it in the form of a cartoon because information is shown in both words and images.
Additional implications of this study could be broadened to other forms of activities that students enjoy outside of class. These activities (like the cartoons used for the study) could be brought into the classroom to increase student attitudes towards science. For example, outside of class students may enjoy watching game shows, playing video games or virtual reality, watching a show, taking selfies and pictures, etc. The success of cartoons on attitude towards and knowledge of science content could create a spark towards the study of these various other forms of engagement for students outside of school (Cetin, et al. 2014). This study could imply the success of these other student interests on student success.

It may be difficult to conclude that this study done at the elementary science level could relate to secondary science students in their more challenging classes. However, though further research should be conducted in this area to prove the correlation and to dive deeper into the differences in engaging elementary vs. high school students, many consistencies are found in engaging students of all ages. The conclusion can be made that cartoons should be utilized at all levels of science education as a form of engagement.

Additionally, Cetin et al.’s (2014) work with cartoons implies that not only does a teacher and/or teaching method have an effect on students’ understanding of the material, but it also has an effect on student attitude to the subject. Contrary to opinion, a change of method in the classroom was actually able to positively impact student attitudes. It is accepted that teachers impact student understanding of material, and thus teachers constantly develop more effective methods of presenting content. However, educators should also put deep thought into how teachers are impacting student attitudes towards science.

What this study was unable to conclude was the connection or correlation between student attitude and student achievement. Both increased in the study but further research should be done...
to conclude if student attitude has a direct effect on student achievement. Thus, if one can control the narrative of the student’s attitude, will that positively impact student academic success?

**Addressing Misconceptions in Science**

The nature of a study by Sattizahn (2015) sought to show that, while student difficulties in science learning are frequently attributed to misconceptions about scientific concepts, it is just as often the domain general perceptual processes of students influence their ability to learn and master difficult science concepts. The study used the concept of the center of gravity to demonstrate that student misconceptions were based on general principles of perception rather than exclusively physics-based conceptual misunderstandings. In general, students’ spatial reasoning and perceptions of objects were more effective at predicting student success on a four question center of mass questionnaire than students experience with physics concepts in the past.

Many studies, especially those within physics education research, have addressed the fact that high school and college students have difficulty grasping and applying concepts taught in introductory physics classes. Often, these misconceptions about physics are identified early in the learning process and addressed through the classroom. However Sattizahn et al. (2015) points out that rarely are basic and domain general (not exclusively physics-based) mechanisms of perception thought as a hindrance to physics learning. This study proceeded to demonstrate otherwise with the specific conceptual understanding of center of mass.

There was no statistical significance relating students’ previous knowledge of physics concepts and their success on a center of mass questionnaire. On the questionnaire, students made very little error, measured in terms of pixels, with either of the symmetrical objects whether it was discrete or extended. The study referred to discrete as one complete object
without breaks or fractures and an extended object as two objects separated by space. In a later interview, 90% of students claimed that symmetric shapes were the easiest, while only 10% of students thought the asymmetric shapes were. Furthermore, 63% of students said that the discrete shapes were easier while 37% claimed extended shapes were easier. This aligns with the data where the error for a symmetric extended objects was the greatest by nearly 20 pixels and the reaction time for a symmetric extended objects was nearly double that taken for any of the other three shapes (Sattizahn et al., 2015).

Sattizahn et al. (2015) claims that this discrepancy in students abilities to answer symmetric discrete center of mass problems vs. asymmetric extended problems has less to do with misconceptions in physics and more to do with students perceptions of objects. The strategies students cited in their interviews to determine the center of mass were threefold. First students looked for the central location, specifically on symmetrical shapes. Secondly, they separated extended shapes into discrete and similar parts. Third, they tried to mentally balance the shapes. The more difficult it was for students to perceive what the shapes would actually look and feel like in real life, the more likely they were to miss the problem. This data suggests that students understand what the center of mass is in terms of a scientific definition, specifically where the object balances, but are unable to apply that knowledge because they don't understand the perceptions of various objects of unique sizes.

This study is limited in that it only studied student perceptions related to a center of mass experiment. To further validate this data to support claims that it pertains to all areas of STEM, more experiments should be done addressing student perceptions relating to other topics in the sciences. This data should be compared with the center of mass data to see if the effects are just as strong and a student misconceptions are unrelated to their depth of understanding of physics.
Furthermore, the study shows that the ability to locate the center of mass of a system is influenced by perceptual characteristics of the objects involved in the task. These perceptual features created difficulty when finding the center of gravity and suggested the features need to be taken into account during the construction along with the physics principles included in this topic. Asymmetrical and extension negatively impacted center of gravity performance, and this negative impact was not accounted for by the amount of physics experience the student had (Sattizahn et al., 2015).

The implications of this study are broad. First, in addition to addressing common misconceptions in physics, the study supports evidence that physics teachers also need to address perceptual and visual reasoning in students to aid their understandings. In this study, students may have understood all of the physics concepts and still missed a question because they were unable to specially reason what the object looked like in three dimensions and how it would balance in their mind. The implications of this study are even broader when you consider the effect it could have on students’ understanding and interpretation based on their perceptions throughout all STEM classes.

For example, a student's understanding of molecules may change based on the perceptual features of the model that was presented in class, whether that be the ball and stick model or a projection on a screen, etc. Similarly, and more importantly, the development of effective STEM teaching methods, student assessment, and classroom intervention strategies relies not only on teaching science content, but also on the general perceptual features that makes understanding them more or less difficult. Rather than teachers simply focusing on difficult concepts in physics to understand, they need to broaden their teaching to take into account students’ perceptions of
the world. Teachers need to address student misperceptions about actual objects and events in the.

Success in science not only requires students to understand scientific theories and equations but then to adapt them to real-world practices. Many classrooms teach the content, and even address common misconceptions in students, but fail to address misconceptions students may have about the objects involved in the problems. For example, students may know that friction is based on a surface and the weight of the object you are trying to push. But students may not be able to visualize that if that object is pushed on its side, and the sides made of the same material as the bottom, the frictional force will remain the same. The reason why students struggle here is not conceptual but rather perceptual, because in their lives they may have pictured a scenario where the object was not made of the same material on both sides and then applied that information incorrectly the physics problem at hand.

What is unique and exciting about science classes is that students come in already having knowledge, because they live in a world governed by scientific principles. However, teachers need to keep that in mind and remember that things in the world are not always exactly as they appear. Teachers need to address student misperceptions about the world when they teach their scientific concepts.

Modern physics in physics class at both the high school and college level has been used as a label for Physics developed since 1895 and the development of x-rays. A study conducted by Zollman (2016) stresses that this is misleading to students and is leaving out the most important aspects of physics, the actual modern physics that excites physicists today. Zollman argues that the term ‘modern’ should be used instead to depict anything that happened post about 1995, when many of the current students were born. He refers to the topics that physics educators
call modern as actually older, outdated physics and claims that introductory physics classes never actually teach students modern physics. Students who take one physics course in their lives never actually learn the current information in physics.

Zollman sites a number of reasons why this is the case. First of all, modern physics is significantly more difficult for students to visualize than the classical physics taught in our classrooms currently. It leads students to many misconceptions, confuses their current understanding of classical topics and may be frustrating. Additionally, most students don't talk about modern physics until after they've learned classical physics. Students then have a tendency to apply their classical physics knowledge incorrectly to modern physics, creating a whole new set of misconceptions. Furthermore, there is currently not available time in physics classes to add a whole new set of topics.

Within the physics community it is difficult to agree on two things: First, what to cut from the current curriculum and secondly, which aspects of modern physics are most important to teach students. Two studies were done to collect research from current physics teachers pertaining to this topic. One was a survey with pencil and paper and the other was a mobile survey in a forum. Both sets of data were compiled to answer the two questions. Pertaining to the first, most physics teachers suggested eliminating one or more of the following topics: fluid dynamics, rotational motion, or thermodynamics. However, responses to this question were all over the board, with no small number of teachers suggesting ‘nothing’ be removed and another group of teachers suggesting ‘everything’. As for the second question, there was a bit more agreement. Some of the highly quoted topics include ‘photons and electromagnetic spectrum’, ‘quantum mechanics’, and ‘special relativity’.
Zollman (2016) then took this data and developed tools to help teachers transfer knowledge of these topics to their students in the classroom. These tools were separated into two categories: tools for non-science majors (for example students taking physics in high school or students taking a science credit in college). This first set of courses attempts to teach modern physics almost exclusively conceptually, eliminating any equations or sets of math to reach students who may not have the depth of mathematical understanding required in current modern physics. The second set of course tools was developed for students in science majors, specifically in college, that go into more depth and are heavily weighted in mathematics. Both sets of materials continue with other visualizations and conceptual activities to help students understand some quantum mechanics and some applications of modern physics to medical imaging. Each of them always includes interactive engagement.

In addition to content and research based pedagogy, significant in teaching modern physics, Zollman (2016) also focused on a third area; delivery method. The information provided in the study includes interactive visualizations such as those used to build models and reference the vast amount of information available on the web. This study also notes a number of the misconceptions that have misled student thinking in the past, such as images of electron energy located in textbooks without labels on the axis. In addition to delivering new content, Zollman (2016) claims that these confusing images must also be removed to prevent students from having dangerous misconceptions concerning modern physics.

There are still some issues and limitations that need to be addressed when it comes to adding modern physics topics to current physics classrooms. First, it would be more harmful to incorporate something with good content and information but with poor pedagogy. More research needs to be done into the interactive engagement learning environment as well as to
informing physics teachers as to how to teach this modern physics content. Secondly, recognizing the need for change is easier than deciding what to do to create and implement that change. The study shows that most teachers recognize that something needs to change about the physics curriculum, and that ‘something’ involves adding modern physics. What is not agreed upon is the best way to add modern physics or to teach it. Further research needs to be done in this area to make successful changes to the curriculum.

Teachers use many representations to communicate the concepts of bonding, including Lewis structures, formulas, space-filling modules, and 3D manipulatives. A study by Bretz, et al. (2014) was twofold in its steps to demonstrate student misconceptions pertaining to this topic. First, 28 high school physical science, high school chemistry, and general chemistry students were interviewed to develop the misconceptions that they gained through multiple representations of molecules in various settings. The interviews focused on identifying student misconceptions about covalent and ionic bonding representations through both teacher generated representations used in the classrooms, as well as student-created representations. The misconceptions gathered from the interviews regarded four basic themes: (1) periodic trends, (2) electrostatic interactions, (3) the octet rule, and (4) surface features.

The second piece of the study sought to use these four misconceptions and the student interviews generated to create the bonding representations inventory. The purpose of this inventory was to quantify the prevalence of these four misconception themes on a much larger scale. The bonding representations inventory was administered to 1072 high school chemistry, advanced placement chemistry, and general chemistry students various regions of the United States. The goal of developing the body representations inventory was to create a quantitative
measure of these understandings, with evidence for the validity and reliability of the data (Bretz, 2014).

The student interviews used to develop these assessments consisted of asking students to create models and discuss a series of expert-generated representations of CCl$_4$, PCl$_5$, and NaCl with an emphasis on eliciting their ideas about bonding throughout the interview process. The students selected for the interviews were at 14 different high schools located within seven different states across the United States. As the test was designed to assess misconceptions about the four misconception themes that emerged from analysis of the interviews of students previously concerning bonding, each question ideally should link up to a specific misconception. For example, questions 5 and 6 contain several statements that measure across these themes. For question 5, students are asked to consider a specific bond in terms of transferring or sharing electrons. Question 6 follows asking the student their reasoning for which type of binding they selected. In this multiple choice question, students can select between a number of different features as to why the electrons are shared or transferred.

Bonding is represented in many different forms to students. While it is beneficial for students to see bonding in these various forms, the limitations of representations are rarely discussed with students, whether that be in a science classroom or textbook. Thus, students can easily develop misconceptions around this and other chemistry topics simply from models they see their teacher use or within the textbook. For example, models that demonstrate the difference between ionic and covalent bonds may lead to students incorrectly believing the ‘stick’ in the model to be an individual covalent bond.

A descriptive statistics and psychometric test suggest that the items on the bonding representations inventory are generating valid and reliable data regarding student misconceptions.
about bonding. Students with more chemistry coursework perform statistically highly significantly better (p< 0.001) for each measurement. Furthermore, the large sample size of 1072 students and a diversity of schools across United States suggest that the bonding representations inventory is likely to be useful in most high school general chemistry settings. Furthermore, it is easy to administer within the classroom in that it is only 10 to 15 minutes in length and can be printed completely in grayscale for students to take with simply pencil and paper. Teachers can use the simple exam as a measurement of students’ ideas and misconceptions concerning bonding. This could be a formative assessment used after a unit or a day in class, or could be used by the teacher to address what students may have learned or misperceived from a previous course they have taken. For instance, an introductive college chemistry course may give this quick assessment to assess student understanding of content based on their high school chemistry experience. The most valuable aspect of the bonding representations inventory is that it is an easy tool for instructors to quickly and efficiently test student understanding of representations and bonding beyond rote memorization of rules. This test addresses deep student misconceptions and allows teachers to match a specific student answer with a specific student misconception.

There are a number of limitations associated with the study, though the bonding representations inventory has been shown to be valid and reliable in terms of data generation. Due to the anonymous collection of data, the exact student wording and answers during the original surveys used to develop the assessment at the high school level are unavailable. As a result, there may be additional misconceptions than the four addressed in the inventory that were not caught during student interviews and thus are not being measured by the inventory. As a result, it is possible that students may have misconceptions that go unaddressed, as the four misconceptions categories may not represent the exclusive misconceptions.
Additionally, further research should be conducted to study various methods to prevent or change student misconceptions. The test only identifies student misconceptions and categorize them into one of four categories. The best prevention of students gaining these misconceptions or best methods of addressing misconceptions in class should be studied further. Similarly additional research would be needed in order to determine casualty of the covalent and ionic bonding misconceptions measured on the bonding representations inventory.

It is fairly well-established that reflection has recently been emphasized as a constructive pedagogical activity. However, while this is well-established, surprisingly little attention has been given to the quality of reflections that students write. In a study by Trumpower (2015), the reflections that student make about their knowledge organization where explored as part of a formative learning activity. Generally, knowledge structures of students studying physics in 11th grade as well as their instructors were assessed using Pathfinder networks. Of the 169 students studied, all of them received a grade A in physics. Of the 9 course instructors in the study, each had at least 10 years of experience teaching physics.

The Pathfinder method allows students to write the degree of relatedness between pairs of concepts. These ratings were based on a 5-point Likert-type scale and then converted through a scaling algorithm into a concept map-like Network. Following the study, each student's knowledge structure was compared with the instructors’ averaged knowledge structure with the purpose of identifying student misconceptions. Each students’ reflection was assessed, taking into account both the correctness of the concepts and their quality of reasoning. After misconceptions were identified, students wrote reflections on the discrepancies between their knowledge structure and their instructor’s knowledge structure. The research group divided student responses into three categories depending on how they constructed their misconceptions;
(1) conceptual, (2) procedural, or (3) declarative. Trumpower (2015) provided significant
evidence that reflection is an effective means of improving student knowledge structure, with
conceptual reflections being the most effective of the three categories.

Evidence from the study can be used to make some significant implications for formative
classroom assessment in future physics and other science classrooms. With recent calls for
assessing knowledge organization as an important indicator of higher-level learning outcomes
arises a need for strategies for fostering the development of students’ structural knowledge.
Reflecting on the differences between a student’s response and the response of an instructor was
shown to be an effective means for improving student understanding of conceptual relationships
that they did not understand prior to reflection. The structural knowledge of the students who
performed conceptual reflection improved more than those who performed declarative or
procedural reflection. Thus Trumpower (2015) found that the higher rating on the second task
with associated most closely with meaningful, conceptual reflection. Additionally this shows
improvement was not due merely to memorization. Students had to reflect with the knowledge
and understanding conceptually to succeed on the second assessment. Reflection in which
students were able to link prior knowledge of concrete examples with new knowledge conceptual
relationships was also associated with great improvements in structural knowledge.

Connecting facts and/or the application of them with the real world was found to be much
more beneficial than simply understanding and association terms. This supports the study's
hypothesis that simply giving feedback to students is not enough, students have to engage with
that feedback and internalized it in order for it to be effective. For example, a student may
understand that force and acceleration are related through the equation \( F = ma \) and they may
have memorized this as a fact. This is of no use to them conceptually unless they can find a
relationship of $F = ma$ to the real world (for example a car accelerating from a red light or a soccer ball that is been kicked decelerating to rest).

There are a number of limitations of this present study. First of all, the type of reflection that students performed with the structural feedback was not experimentally manipulated. Further research would need to be conducted to determine the relationship between the type of reflection and post-test structural knowledge. Additionally, each student studied physics under a different instructor who provided students with different levels of conceptual knowledge and different activities in the class despite the fact that all students studied the same general topics. The different types of instructions may have influenced students’ understanding or interest in various topics. Furthermore, because so many different concepts were studied in this experiment, students may have become bored with rating many items on the assessment provided by the research team and thus did not analyze as many topics as they could have simply for feeling fatigued.

Trumpower (2015) does make some major conclusions on the reflection of structural knowledge causing students to better understand physics concepts in this study. This has significant implications for teachers as they give students feedback. Teachers should encourage students to think of concrete examples of the real world that illustrate the concepts are trying to learn. Additionally, when providing feedback to students, teachers should give students time to engage with the feedback in a very meaningful and concrete matter. Students who can reflect more conceptually should be expected to benefit more from structural feedback while students who reflect more procedurally should be benefiting more from other types of feedback. If instructors provide feedback in multiple ways, more students have a chance of being successful and changing that feedback to use for conceptual knowledge.
It is well known in the scientific community that scientific writing and communication of data is extremely important. A study by Burgoyne (2017) presents an overview of a curriculum bedded Engineering Communications Program that addresses this need to acknowledge the importance of writing instruction in science and engineering. Furthermore it creates a plan proposed to help students learn to communicate more effectively.

The engineering communications program was inserted into the curriculum at Virginia Polytechnic Institute and Virginia Tech. The results of this communications program has positively impacted the material science and engineering curriculum by providing technical and professional communications instruction and feedback to students. With the purpose of enhancing students’ ability to communicate, the program provides substantial instruction and written, oral, and visual communications. As part of the engineering communications program, staff members teach courses, conduct workshops, tutor students, grade writing and speaking assignments, and conduct regular programs. As far as implementing this curriculum, the research group, primarily made up of professors, established helping students communicate effectively and efficiently to prepare them for the workplace as the primary goal.

The engineering communications program used in this study emphasized four main pieces, which they referred to as ACDC. First, audience awareness. Secondly, context awareness (referring to identifying explicit and explicit goals for communication in different settings). Thirdly, document design, meaning adaptations in content, organization, language, and tone. Finally collaborative and management skills. The communications instructor was involved during the entire process of the communications assignment and is given time to work with the student inside and outside of the classroom to provide constant and consistent feedback. This engineering communications program was implemented in 16 engineering courses containing
roughly 400 students. In order to ensure correct implementation of the approach, the instructors involved collaborated closely to develop the communication requirements that were identified as the most relevant in academia and industry.

This study found much success in their push for improved communication for STEM students at the college level. It has significant implications for teaching engineering students at the college level and below how to communicate with their peers and other audiences in this style. As of 2016, to show the successful implementation of this program, assessments demonstrate that the majority of students and advisory board members regard the engineering communications program as essential to educational and professional growth. Students realized the significance of their growth, as referenced in student interviews and surveys. Student cited in their content that language and context were highly intertwined and also realized that they were able to adjust their communication skills according to different genres and audiences.

The communications program found new successes comparing students in groups of four to five and having them create more intricate projects, posters, and research papers. The team used Google docs to provide consistent and quick feedback throughout the project creation process. They found so much success that the program is now overflowing with students.

The implications of the results from Burgoyne (2017) are broad. Many students learn communication skills predominantly in their English classrooms, such as writing and public speaking. However, this type of communication looks very different than scientific communication through writing and presentations. English classes typically challenge students to create ideas and instill thoughts or emotions in their readers through language. In sharp contrast, scientific writing requires students to be as concise, straightforward, and clear as possible. Students need to learn how to express complicated concepts and terms in a method that makes
sense to a variety of audiences. STEM students also need to learn how to present a difficult experiment in a clear manner that allows their listener to understand and get enthusiastic about the same topic. Currently, students have very little opportunities to grow their ability to do this in their science classes, where the focus is very often not on communication. However this is the skill that appears to set students apart when they get into STEM fields post college graduation.

One limitation of the study by Burgoyne (2017) is that it was done at a single college in a single program. Though there were a good number of students and professors involved in the study, this is just one demographic of the population. Additionally, this research study came out of a single college, with their own students, professors, and research team. It is possible that the team may be over-optimistic about the success of the program in order to make their own program look better and gain future students of interest. It would be intriguing for future similar studies to be conducted at another college, or even more significantly across many different universities around the United States.

**Formative Assessment**

Recently formative assessment has been widely discussed as an effective strategy for supporting student learning. In a study by Annika Lena Hondrich (2016), the group sought to evaluate teachers implementation fidelity of a curriculum imbedded formative assessment program specifically for primary school science education. This study investigated material supported, direct application, and subsequent transfer based on formative assessment. Of a group of 17 German primary school teacher studied who participated in professional development on formative assessment, 11 teachers formed a control group while the other six formed the test group. Teachers’ implementation fidelity was evaluated for classroom observations, student
ratings, and an analysis of student workbooks. These evaluations focused on frequency and quality of intended formative assessment elements (assessment, feedback, and instructional).

The motivation for this study is clear; many studies have shown the positive impact on student learning that is correlated with the increased use of formative assessments in the classroom. The challenge comes from how and when teachers implement these formative assessments most effectively. Additionally, it is challenging for teachers to find the time to create assessments as well as develop a knowledge base with which to create an effective formative assessment. This specific study aimed for teacher implementation fidelity and evaluations of variables connected to teachers’ implementation fidelity.

Overall, the results of Annika Lena Hondrich (2016) showed the test group teachers’ implementation fidelity to be high with slight variations in quality. In terms of transfer, teachers still implemented more formative assessments and elements then the control group, though implementation fidelity was significantly lower. In terms of the first research aim, “teachers’ implementation fidelity”, treatment teachers had a high frequency of curriculum embedded formative assessment and the direct application condition. In contrast, the control group teachers used to none of the curriculum embedded formative assessment strategies planned in the intervention. These strategies included written diagnostic tests, written individual feedback, and assigning specific tasks to students. Furthermore, the differences between the treatment group and the control group were statistically significant, tested with the Mann-Whitney u-test which had a final p value of p=0.01, with p <0.05 referring to statistically significant data. However, though the data shows a significant difference in the use of formative assessments between the control and treatment teacher groups, students perceived no difference between the two
assessment strategies, rating their teacher’s use of formative assessment strategies exactly the same in both scenarios.

Pertaining to the study second research aim, “relationship between teacher variables and implementation fidelity”, Annika Lena Hondrich (2016) investigated correlations of a group teachers’ implementation fidelity with their knowledge of student misconceptions. Knowledge of student misconceptions was shown to be positively correlated with all implementation fidelity scores. Teacher evaluation of the program was predominantly positive, on average they evaluated the formative assessment elements and materials as “rather adequate for fostering student learning and motivation”.

This study is valuable in assessing the success of formative assessment in the classroom. Formative assessment is accepted as a method to increase student success but there is much variation associated with this. Having teachers participate in a workshop dedicated to research-based approaches to formative and then determining, out of their own motivation to attempt these methods in the classroom is an effective way to test success of strategies in the classroom. This study speaks to the significance of not simply providing increased formative assessments in the classroom, but to considering how the formative assessments are constructed. For example, what tools are teachers using to assess students and how have those tools been contrasted to address student misconceptions?

Annika Lena Hondrich (2016) sought to implement curriculum via the format of assessment in primary school science classrooms, presented a number of limitations. The first and most obvious limitation is the small sample size of 17 teachers, 11 of which were in the control group. Furthermore, regarding the group's second research aim, other factors than those referenced in the study may have been influential and were not held constant in this experiment.
For example, student achievement levels may have been based more on the knowledge of content, teaching style, or professional experience of the teacher then on the teachers’ choice to implement the formative assessments as assessed in this research study. A future study could be formed to focus on the achieved treatment. In other words given the same teacher, teaching style, etc. does the use of formative assessment intervention positively influence student outcome? In this study the teacher would be held constant and changing the rate and style in which they use formative assessment would be altered, thus eliminating the chance that data positively correlated to the use of formative assessments in the class could really just be related to having a more qualified teacher or teaching style.

**Research Support for Capstone Project**

**Purpose of Grades**

Receiving an A in a class should mean that the student has mastered the material required for the class almost completely. Frank Noschese, a physics teacher at John Jay high School in Westchester, New York, noticed that a number of his 11th graders were able to get A’s in class without actually mastering any of the complex concepts (Spencer, 2012). Noschese wanted to create a method for grading that would encourage students to move from easy concepts to hard concepts and reward those for ultimately obtaining knowledge, no matter how long it took. It was from this desire, along with some significant prior research, that Noschese developed a method of standard-based grading. Overall, the goal of standards-based grading is to make grades more meaningful for everyone and to use them as a learning tool rather than a judgment for students.

As part of his standards-based grading methods, students who failed a concept during a quiz would have second and third chances to master it. Mastering the concept the second or third
time could look anything like taking the quiz, conducting a lab experiment, or simply sitting with the teacher to explain it to him. Then when students took a quiz or test, they did not see it represented as one single grade but rather broken down into multiple pieces each representing its own individual concept. The root of the idea behind mastery grading is that teachers should have an idea of what standards students should master. Spencer (2012) holds the view that traditional grades are often based on varied criteria and are therefore unreliable. Furthermore, traditional grades don't tend to place enough emphasis on what is truly important, students reaching proficiency in whatever subject matter. However, typically students are often rewarded by grades for successes that are unrelated to their conceptual understanding, such as class participation, following directions, or bringing in tissues for the classroom.

As there is a push to grow the educational base in the United States, and for students to succeed on new common core assessments, various types of grading methods have been developed to improve upon the traditional grading methods. Standard based grading in particular is very different than traditional grading, both in terms of how it's played out in the classroom as well as how it appears on students report cards. In standard based grading, students should have multiple opportunities to remaster objectives. Students should be well aware of which standard is represented by various assignments and teachers should be clear what information is necessary to understand each standard. In terms of the report card, rather than receiving a single grade for each class, students should receive a grade for the class followed by a derivation of where the grade came from based on the number of points the student earned associated with each of the standards. This student could then be separately scored on effort grades, such as participation, homework, cooperation, and punctuality. These grades would not go into the letter grade but rather into a work ethic type system (Spencer, 2012).
Spencer (2012) implies that in addition to providing students with an opportunity to relearn and to understand what they do not know, standard based grading allows the school to provide more differentiated instruction. The reason for this is in an ideal standards system, students know exactly what they know and don't know. Students can then be more independent with improving their grades and relearning what they've missed. The teacher and students are both aware at any one time which standards the student needs to master still. Furthermore, in this era of computer-based learning, students are given the chance to pick to do the questions that they're struggling with conceptually, given the option to do various standards on the computer program.

Though there are many successes to standard based grading, there definitely are some challenges. First of all, Spencer (2012) states that it does require more time than traditional grading. Secondly, a small study of 77 seventh graders showed that no matter how students are graded, they tended to score more or less the same on the exam. Additionally, some parents resist the reform saying that these report cards are hard to follow and difficult to read. Many are concerned that students will lose their motivation to study for test when they know they will have multiple opportunities to make up for bad scores. Parents argue further that students will not be given this opportunity and higher-level courses and those are developing bad habits. Finally, while it is more helpful for a 6th grader to know that she is partially proficient in multiplying fractions then that she has a B in math, it can be frustrating to read columns of information on a report card. School districts would need to put extensive thought and consideration into how new report cards are to be written.

So there are some disadvantages to standard based grading they will need to be reckoned with, Spencer (2012) acknowledges the startling amount of information that standard based

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grading produces, from report cards to re-teaching to differentiation. It also makes people more honest with their grading. A number on the standard shows the extent to which a student understands that standard.

When it comes to standards-based grading, even following the same guidelines, teachers have a number of disagreements. Julie K. Wischa (2018) addresses the grading gradient, referring to how teachers implement and allow students to redo and retake work. Standard based learning requires that students have an opportunity for a reassessment of standards that they missed, however many teachers note that students are being assessed at the end of the course rather than at pre-determined intervals. Additionally, the extent to which teachers can allow redos and retakes is not only affected by their own motivation but it's also affected by school policies, content area, and important student deadlines.

A study by Julie K. Wischa (2018) surveyed 429 secondary teachers to quantitatively assess their grading practices and to evaluate their connection to standard based grading in order to establish a version of a gradient. Three potential obstacles to unanimity in grading policy were considered and studied. First, differences of opinion of best practices in terms of standard based grading between teachers. Second, day-to-day realities make recommended practice inappropriate for specific classrooms. Third, teachers lack sufficient knowledge and skill. The motivations individual teachers used to implement specific greeting policies or studies as well as what their specific grading practices were reviewed through survey questions to secondary education teachers. The survey asked these teachers five questions. The questions involved the teachers understanding of standards-based grading, the extent to which they allow redos and retakes in their classrooms and schools, and finally what students’ attitudes are towards retakes and standards-based grading.
The results of the survey to teachers showed that 41% of teachers indicated that their school had a standards-based grading policy. The extent to which the policy was followed by all teachers and the definition of standards-based grading varied between schools and teachers. Secondly, concerning the attitudes of students and teachers on retakes, the survey found that student attitudes towards standard based grading was a reflection of student ownership and accountability. Furthermore, teachers who allow redoes and retakes and who are involved in standard based grading still often tend to adhere to traditional grading measures when it comes to allowing non-academic factors, such as student behavior, meeting deadlines, etc., to contribute to the grade earned. Julie K. Wischa (2018) found that 28% of teachers allowed retakes only on homework assignments, 15% on all graded work, and 8% did not allow retakes on any work.

Furthermore, teachers have varying beliefs on what offering a retake does for students. First, some teachers believe that it effects student ownership. Ironically, both teachers who argue for penalizing students for late work as well as those who argue against late work penalties both site the same reason. Their reasoning is to increase student ownership of their grades and the content. However, teacher beliefs about the importance of deadlines influences how they choose to offer retakes. Some teachers who fell in this boat do leave offer redoes at all while others offer them only for a week after the due date. Those who honor strict deadlines argue that the real world does not leave room for retakes nor doesn't have flexible deadlines.

One of the major takeaways of the study is that further research needs to be done into the value of student retakes and how to balance allowing students to remaster content with being consistent with student expectations. Do redoes encourage students to slack the first time? Or do redoes allow more students to master the content than with only a single test? While 92% of the
teachers surveyed are implementing redoes and retakes in their classroom, less than half of these teachers are doing so at a school that is following a standardized grading curriculum.

It is incredibly clear from the study that teachers at-large need more information and specific instruction around the use of redoes and retakes in their classrooms. Teachers lack sufficient knowledge and skills needed to implement standards-based grading policy effectively in their classrooms. Additionally, the survey was limited to the population distribution of the region, where most students are concentrated in 5 large high schools. This survey could have more statistically significant results if given to a larger and more diverse population of teachers in the future.

Methods and Benefits of Grading by Standard

There are a couple problems with traditional grading methods. One of which is the inconsistencies that lie in the somewhat random assignments of numbers to students, even within the same school. A study of 2419 students at 11 high needs high schools in Kentucky demonstrated some of the outcomes of making the switch from traditional grading styles to standards-based grading. The study set out to answer three questions. First, does a stronger association exists between standards-based grading and standardized test scores than with traditional grading practices? Secondly, does a stronger association exists between standards-based grading and minority standardized test scores done with traditional grading? And thirdly, does a standard based grading method across a school increase consistency among teachers and meaning of grades among students and parents? Pollio (2016)

First off, weeks after implementing standards-based grading, Marty Pollio, principal of one of the 11 Kentucky high schools, made some significant observations. Though he still continued to have the same number of conversations with teachers, students, and parents
concerning student grades, the conversations veered away from the typical grievances-complaints over a couple of percentage points, begging for bonus, etc. The new conversations about grades centered on student understanding and misunderstandings. Conversations about bringing up grades focused on students’ access to additional learning opportunities and reassessments for concepts that they had previously missed. Pollio (2016)

It is clear that inconsistent composition of grades in the same school weakens the meaning of grades for students. Students CA number associated with their grade rather than a concept or lack of understanding. Students recognize the variability of traditional grading systems and we'll use that as an excuse or a target for argument. Countless studies in the past, dating back to the mid-1900s, have questioned the meaning of grades and their validity. One such study referred to grading practices as "hodgepodge". With standards-based grading, the mindset of teachers, administrators, students, and parents switch away from numbers to concepts and understanding. To implement standard based grading slowly in the 11 inner city high schools studied by Pollio (2016), standards were introduced slowly with teachers being required to focus on three key standard per grading period.

To address the first two questions, the relationships between students standardized test results and grades for the 2011 year were compared with 2010 student grades for algebra and science. Both subjects were studied to eliminate the effects of a single cohort. Through this data comparison, Pollio (2016) found a positive but weak correlation between traditional grades and standardized test results. Though students with better grades tended to score better, grades did not reliably predict the standardized test scores. In comparison however, standardized test scores showed a much stronger correlation between grades and standardized test scores. Students who received A's and B's in the class also tended to receive A's and B's on the test as well. In terms of
the second question, minority students in these districts in Kentucky also showed gains in their results over the two year period in their study group of 1256 students. The first year, after a year of traditional grading, on the standardized tests for math and science 24% demonstrated proficiency, receiving grades of an a or b. The second year, that same group of students after completing a year of standards-based grading demonstrated 55% proficiency (Pollio, 2016)!

Though the results of the study are largely positive in favor of standards-based grading, there are a number of limitations to using it in the future. First of all, to switch a grading system, especially at the high school level, is a huge step! Additionally, this requires teachers to be trained and knowledgeable about what standard based grading is and is not. A second concern from teachers is that they struggled to assign poor grades to conscientious students and feared that the low marks would discourage their positive behaviors. Teachers wanted to grade students on their attitudes and attention rather than on if the student understood the concept. Finally, there are so many factors that affect the success and the growth of students. Further research should be done to determine the effect of standard based grading on student success on standardized tests. It cannot be scientifically proven at this point that the success of the schools in Kentucky is based on the switch to standard based grading. The misconception should be avoided that standards-based grading is a school improvement potion. As a disclaimer, standards-based grading might be necessary and helpful but is not sufficient on its own to create a successful school with successful students (Pollio, 2016).

The implications of the study are vast! If it is true that standards-based grading allow students understand what their grade represents and to be motivated to increase their conceptual understanding, this is a huge leap forward in the right direction! Additionally, if simply switching a school's grading system schools increases standardized test grades within a year,
more schools need to be getting on board with this practice! Finally, it has been shown the standard based grading helps economically disadvantaged students as well as minorities to close the learning gap on standardized tests. If educators can move from having meaningless conversations about random numbers assigned to students as their grades to heaven meaningful conversations with students and families about misconceptions and remaster assignments, imagine what successes could follow!

An incredible amount of research on grading has been conducted over the past century. The tides have swung between various grading policies and many studies have investigated into the best and most useful practices for grading. Brookhart (2016) sought to composite as much about literature from the past century as possible concerning grades and to synthesize that information into a number of consistent and applicable conclusions. As a whole, teachers tend to believe, and demonstrate in the grading practices, that grades assess a multi-dimensional construct containing both cognitive and non-cognitive factors reflecting what teachers’ value in student work. These grades should be multi-dimensional measures of academic knowledge, engagement, and persistence. One of the five categories citation focused on is standards-based grading. A review of the benefits, negative, and weaknesses of the standard based grading movement were reviewed.

First, it should be noted that standard based grading is differentiated from both standardized grading, which provides teachers with uniform grading procedures in an attempt to improve consistency in grading methods, and from mastery grading, which expresses student performance on a variety of skills using a binary mastered vs. not mastered scale. Many assert that standard based grading is an improvement on both of these prior standards-based grading methods. Some educators argue that standards-based grading can provide exceptionally high-
quality information to parents, teachers, and students and through that will bring about instructional improvements.

However, there are a number of serious downfalls associated with standards-based grading. First, standards-based grading may be no better ultimately than these other reporting formats and is potentially just a result of a new short-lived educational movement. It may be subject to some of the same misconceptions as the other grading scales. Secondly, literature on standard based grading implementation and recommendations is extensive while empirical studies are very few. Most studies focus on implementing rather than on the relationship on standard based grading to student improvement. Third, schools, districts, and teachers have experienced difficulties implementing standards-based grading. They struggle to understand how the system works successfully, especially grading on standards and separating achievement grades from learning skills. Teachers also struggle to implement common assessment, follow minimum grading policies, allow students to retest and replace a poor test score, and accept late work with no penalty. All of these are foundational qualities of standards-based grading.

However, Brookhart (2016) found that overall parents, teachers, and students seem to prefer the standards-based report cards over traditional report cards. The record includes detailed information that takes teachers longer to put together. Still, teachers overwhelmingly feel the time was worthwhile. Parents and students appreciate the communication they get through this report card.

When it comes to high-stakes testing and the relationship of grades to standard based grading methods, Brookhart (2016) asserts the relationship to be slight to moderate, since standards-based grading was only a small indicator of student success on high-stakes
assessments. However, some argue that this could be due to teachers including non-cognitive factors (such as attendance and participation) in grades or miss-labeling and scoring standards.

Brookhart (2016), as a result of synthesizing a hundred years of grading research, arrived at a number of significant implications for educators. First, teacher-assigned grades have been judged by researches and psychiatrists as subjective and unreliable measures of student achievement academically over the past hundred years. Others however, have noted that grades are useful indicator of numerous factors that matter to students, teachers, parents, etc. Interestingly, the standardized assessment scores show low criterion validity for overall schooling outcomes, high school graduation, admission to colleges and universities, etc. Grades consistently predict k-12 educational persistence, completion, and success transferring to college. This demonstrates that teacher assigned grades, though inconsistent, has consistently predicted student success beyond high school. Furthermore, these teacher assigned grades to represent both cognitive knowledge and non-cognitive factors such as engagement, persistence, positive behavior, etc. The most conclusive reason for this finding is that grades typically represent a mixture of multiple factors that teachers value. Teachers recognize the aspects they grade as playing an important role in achievement and motivation. Teachers tend to differentiate academic enablers like effort, ability, improvement, work habits, attention, and participation as being relevant to grading, while characteristics like gender, socio-economic status, or personality are not endorsed as relevant to grading. Current theories suggest that both these cognitive and non-cognitive skills are important to acquire and build over the course of life and are necessary for student success in the future. Both should be learned in the classroom, not only the standards taught in the content.
Besides academic content, there are two major components that teachers value and thus include in student grades. The first is student effort and the second is fairness. However, it is clear that teacher grades and grading styles vary. To teachers given the same assignment to grade will often assign a different value. The two main reasons that teachers arrive at different values can be drawn back to teachers emphasizing different criteria of importance in the assignment.

Standards based grading, or grading according to learning targets and concepts is nothing new. As current grading systems continue to gain more scrutiny based on their apparent arbitrary assignment of values, it is time that educators switched from this grading framework. Shippy (2013) claims there are many evidence-based reasons pointing to the need for the switch. First, grading scales that include homework, behavior, attendance, notebooks, group work, and participation should not be factored into the student's grade. Homework grades, for example, have been known for years to not accurately express student understanding. Much of homework is done by students very quickly without much effort, or assignments are even copied from their peers quickly before class. This is not an effective measure of student understanding. Homework, behavior, and attendance do not have any bearing on what students know or how much they may have mastered content in a class. Standards based grading suggests that all students should be graded solely on their mastery of course content. While many educators have actually woven in parts of standard based grading into their curriculum and pedagogy, this attention to mastery should be even more emphasized while any non-mastery bearing content should be minimized.

Not only should be standards be used in grading, they should also be used as guidelines in designing curriculum. Backwards planning, firmly supported by previous studies, has undeniable benefits. Backwards planning refers to the teacher planning from the final assessment backwards throughout the class and helps keep the focus of the class on standards yet to be
learned. However, while the teacher may be very familiar with where the students should be in terms of understanding at the end of a particular unit, often these expectations and milestones are not effectively communicated to the students. They do not always know what is expected of them or what they should expect to gain from the next assignment. The key to communication with the student is clear and concise standards with precise levels of mastery (Shippy, 2013). With a clear set of standards, teachers can develop formal and informal assessments to gauge student learning and students can easily interpret data to determine for themselves how well they mastered the various standards on the assessment. Furthermore, teachers can more easily establish intervention strategies to help struggling students. Students can then advocate for their own learning and pursue these targets.

Shippy (2013) notes four types of targets that can be used by students and teachers to guide learning standards: Knowledge targets, what students need to know; reasoning targets, what students should be able to do with this information; skills targets, how students demonstrate mastery; and product targets, what students can make to show their learning. With these targets in mind, students will be more aware of the goal of a particular unit or semester. In the rollout of various projects or units, the teacher can share with students the learning Target to be mastered throughout the assignment rather than simply sharing the activity or assignment with students.

The greatest promise of mastery grading seems to be the ability to put the student in a place where they understand the domain of knowledge so each student’s progress can be measured entirely based on his own individual efforts. Students are thus motivated and encouraged to see their growth through the unit or course as they master standards.

Shippy (2013) sites that there is much potential for student learning when students can see the breakdown of each concept instead of receiving an ambiguous percentage on a test.
Seeing a breakdown of points allows a student to assess their own learning for each standard. Students can see which standards are mastered and which ones need more work. With the option of reassessments, students still have the opportunity to master the standards even after the assessment. Teachers have the opportunity to address their instruction to best help students.

One of the major future benefits of mastery grading is the ability for students to have a clear understanding of how they would be evaluated in the professional and post-secondary world. Parents noted that standards-based grading is similar to workplace evaluations. For example, in a doctoral degree program students are given milestones that need to be reached by the end of the semester. At the conclusion, they write a reflection linking activities after each competency. A practice in mastering grading allows students to be better prepared for how true assessments in the workplace function (Shippy, 2013).

Many educators have been struggling for years with the best system of grading for high school students, feeling that traditional grading systems are meaningless and arbitrary. Miller (2013) suggests a better grading system using student centered assessment and standards based grading. The purpose of this method is to individualize how students learn, grow, and receive feedback in high school. This method’s purpose is to bridge the gap between the need for some type of grading system to communicate student skill levels to colleges and the seemingly random assignment of grades to students with very little meaning associated with them.

One of the main problems with the current grading system of high schools is that students see it as the sole definition for success. When Miller (2013) asked a group of students what they would define as success, the overwhelming response was getting the grades necessary for college admission. By this definition of success, high school students work with the motivation in mind of some distant hazy future where they will eventually have the job they want, security, and
happiness to make the hard work in high school worthwhile. Having this knowledge of student views allowed Miller (2013) to realize that there is something wrong with the current high school system if the only incentive students have is to make grades. Most teachers cite the goal of wanting their students to learn, not simply pass.

One of the major ways Miller (2013) suggests to address this problem is to find a way to assign students grades that have meaning overall in the classroom and not just for individual assignments. Purposeful assignments should be graded frequently with detailed feedback for students to learn from. The reference point used should be specific objectives, standards, or other learning goals specific to the class. While this would not change the fact that students would hand in assignments, the purpose of these assignments for students would alter. Rather than being assigned random grades for various assignments, students should be assigned grades for success on each standard. Instead of the goal being a good grade the ultimate goal would be mastery of standards.

In addition to providing students an understanding of the meaning of their grades, it also allows the teacher to create a more differentiated classroom. While students are of course still required to complete and hand in assignments, the assignments do not have to be exactly the same for each student, nor do students need to have the same number of assignments. The standards-based approach holds students accountable for work they need to do to ensure that the work each student does is to progress in their own individual learning. This thus allows the teacher to assign and alter work based on what the student needs; it leaves the teacher free to provide students with the various materials they will benefit from and leaves the student free to concentrate on learning and progressing. If a student has mastered a particular standard, they no longer need to complete assignments that focus on that standard and can focus on another area.
with content that they may struggle with. The standards-based grading is there for a student-centered approach to assessment. It requires that the teacher notice each student's strengths and needs and act on this knowledge. It also requires the student to respond to feedback and know their own strengths and weaknesses. This type of differentiation does not release students from completing assignments but simply allows students to do assignments that allow them to progress rather than for the sole purpose of protecting their final grade.

One misconception about the standards-based and student-centered assessment is that students have less responsibility and have a tendency to be lazy. However, quite the contrast is true. All activities are assessed all the time but the activities being assessed are those that will help and encourage individual student growth. Miller (2013) recommends teachers not to grade individual activities but only the totality of students’ work, and that is based on each standard. This allows the teacher to spend significantly less time on bookkeeping so that more time can be spent on conferring with students and responding to their work with feedback. Students require timely feedback on work in progress and consistent suggestions. Teachers have the time and resources to respond to each students’ need and provide feedback to allow the student to progress. One of the most convincing arguments is that we can trust students to want to learn when they are sure it is their learning rather than their compliance that is our first concern.

One of the limitations of this study is that Miller (2013) collected their own data within their own classroom. The results are convincing, providing any educator with something to think about. However, further work should be done to see if these methods transfer effectively to other high School classrooms and other high school subjects.
Making Grades Meaningful

Teacher education programs tend to, of course, heavily favor teaching methods useful for within the classroom, classroom management, best practices, etc. However due to a recent study by Jennifer Randall (2010), it appears that more focus and teacher educational programs should be given to the grading practices of teachers. This study showed that teachers, even within a district that emphasizes that grades should be determined by achievement only, tend to add other student qualities into grades as well. The primary purpose of the study was to clarify the meaning of grades while examining some of the factors that teachers include when assigning students a final grade.

The sample used for the study consisted of 516 public School teachers from elementary, middle, and high school. Each school teacher took a 53 item survey created by Guttmann’s mapping services. This data was analyzed and synthesized to create the findings of the study. The survey intended to study the four way between subjects with the student characteristics ability, achievement, behavior, and effort as the independent variables and the final grade students received as the dependent variable.

Many parents think that their student’s school is doing a good job, despite evidence suggesting that education and student overall knowledge is declining. The reason for this is that parents are relying primarily on the grades on the students’ report card, and as long as student grades look fine, parents are generally pleased with the education. The question remains, do student grades represent actual student achievement? It is well accepted that the primary purpose for grading and the report card is to communicate with students and parents their achievement of class content. Basically, grades should be a representation of student achievement. However it is also well-known the teachers often assess factors other than achievement when determining student grades. Some of the reasons for this are that teachers feel behavior should be considered
along with student achievement. Furthermore a student with a higher aptitude should work at a higher level, while student who works very hard, but do not reach the same level of achievement should be rewarded for their hard work. Teachers feel it is difficult to measure the difference between aptitude and achievement.

Through the study, Jennifer Randall (2010) found that 61% of teachers reported considering measures such as behavior and effort, in addition to achievement when determining grades. Additionally, 31% of teachers agreed or tended to agree that the behavior of the student should affect the grade. 37% of secondary teachers reported that they consider conduct and attitude when assigning final grades.

In terms of the survey results on behavior, ability, achievement, and effort, findings reveal a statistically significant relationship (p<0.0001), suggesting this significance is not based on sample set alone. Among the findings of typical grades associated with student qualities, Jennifer Randall (2010) found that with high effort and excellent behavior, a student with low achievement (reported at a 69%) and low ability received on average a grade of a 76.8%. Students with low effort, excellent behavior, and high achievement received grades of 90%. In cases where the student was on a borderline between two grades, teachers relied even more heavily on other student characteristics then listed above.

Grades, when assigned appropriately and based on achievement, enable teachers to compare knowledge and skills of current and previous students. Additionally, grades allow teachers to accurately determine the preparedness of incoming students and the students they are sending to the next level. This would also provide parents and students with a clear picture of their knowledge and understanding of the content of the course at hand.
There were a number of limitations in the study. The most significant one being that although the scenarios in the teacher survey were independent of each other, teacher responses were not. It can be assumed that teachers found the apparent patterns in the survey and relied on previous answers to answer new questions. Therefore, the survey questions were not completely independent from each other as interpreted and this may have influenced teacher responses.

The implications that can be asserted from Jennifer Randall (2010) are broad. First, this study provided useful information about the grading tendencies of k-12 teachers. Additionally, it encourages more information to be provided to teachers concerning grading policies while they are still pre-service. Grading practices that consider other factors than grades can create less reliable grading methods and miscommunications between parents, teachers, and students. Finally, school administrators should use this information to design in service teacher trainings and professional developments around the purposes upgrading.

Much of the research in education shows that grading and reporting are foundational elements in every educational system, but the key to keeping the system healthy is making the grades meaningful. Guskey (2015) performed a study noting various research sources on grading methods and synthesizing these sources into a number of conclusions when it comes to grading. Through this process, this study established multiple qualities necessary for effective grading methods based on the most current and up-to-date research studies. The first step in sound classroom assessment practices is to ensure that the grades are meaningful. However in current classrooms, teachers typically merge scores from major exams, quizzes, projects, labs, etc. with homework, punctuality, participation, effort, etc. added in as well. The current grading systems provide various weights to the categories based on how the particular teacher would like them
weighted. The result of this system is often a systems that is impossible for students to interpret accurately or meaningfully because they do not understand where the grade it coming from.

As most educators would agree, the purpose of grading is to describe how well students have achieved the learning objectives or goals for the class. Given this purpose, teachers need to focus their grading efforts, at least the ones that factor into the student's GPA, solely on course content and standards. Some research recorded in Guskey (2015) suggest also adding what is known as progress criteria to student report cards. These are other grades associated with items outside of content mastery, such as student gains, improvements, value-added learning, and educational growth. These are ways for students to be proud of and measure their improvement over time. If teachers reported multiple grades for the various criteria they do not have to worry about how to weight the scales or combine grades. As a result, students can clearly see the grade calculations so they know where their score came from.

When it comes to reporting grades, Guskey (2015) suggests a number of best practices. First, it is most important that teachers know the domains well and create student learning standards based on these domains. Teachers need to clearly distinguish and define what each domain entails. In this process, the study suggests that typically three to five standards are appropriate for any given subject or tests in class. Teachers need to consolidate and create reasonable standards for students to align their learning to as they prepare for each assessment. Additionally, success in reporting will be instantly improved as internet-based applications are developed to allow teachers to record student performance and to determine grades. As these applications are developed, they should be teacher friendly and include procedures for distributing report cards to students.
Along the same lines, the standards-based report cards should be personalized with all of student’s information in addition to teacher’s names and photographs. The achievement grade should be based on the evidence of students’ academic performance and not include any non-academic factors. However in addition to reporting academic achievement, process goals related to participation, cooperation, homework, and punctuality can be developed and reported as well. Furthermore, Guskey (2015) focuses on the fact that grades are most effective when they only reflect achievement. Grades can be used as a powerful tool of learning, or can discourage and confuse students and distract from the learning. The soundest classroom practices associated with grades is to make them meaningful. The second most important element is to identify factors that relate to achievement in direct or indirect ways, in other words teachers must decide what evidence best serves the purpose and use that as part of the grade. These grade reports should be based on a large body of evidence provided by the student and reported by the teacher. The summer should be clear and useful and represent students’ knowledge base, not how they did on a single assessment.

The implications for this study are vast. First, the goal of grading and reporting is to enhance student learning. To create a better learning environment, much focus should be given to reporting grades, where grades are valid, reliable, fair, and useful. This is a non-negotiable point if we want to link grading and reporting with students’ mastery of content and practice standards. Additionally, Guskey (2015) notes that all grading needs to start by having a clear purpose and that purpose needs to be followed by an in-depth understanding of the criteria used to create the grades. However just as important is the effort to link curriculum standards with grading and reporting systems. Teachers need depth of understanding of their own content in order to arrive at consistency, validity, and fairness in grading. Grades should and can be thought of as a
roadmap of student progress and achieving their learning goals. Ultimately, Guskey (2015) notes that grading and reporting are just some very important tools to help us achieve what matters most, improving student learning.

In traditional grading systems, students acquire points for various activities, assignments, and behaviors. These grades are built throughout the grading period and the teacher adds up the points at the end to assign a letter grade. Heflebower (2001) suggests that these practices provide little useful information about a specific student and their knowledge base. A letter grade B could be given to a student for any number of reasons. For instance, a particular student may have a poor understanding of content but has been well-behaved in class, participates in discussions, and turns in all assignments on time, and thus receives a B. Another student may have a perfect and complete understanding of content but be given a B because of number of late assignments turned in or poor behavior. Furthermore, two different teachers given the exact same student scenario may assign different grades for the student depending on their respective differences in teaching philosophy. One teacher may give the student a letter grade of A while the other teacher gives the same student a B, but the student has demonstrated the same amount of learning in the classroom.

The goal of an effective standards-based grading and reporting system eliminates the overall unknown grade. In place of the unknown, the teacher should score specific measurement topics for the students. These topics are broken down by the teacher determined standards and graded solely on student mastery.

In addition to the break-up of content by standard, Heflebower (2001) suggests using the 0.0 to 4.0 metric scale as opposed to the 100 point scale. The main reason being that the 100 point scale is not useful for tracking student progress with multiple standards at the same time.
Even if a teacher decides to split the test set by standard, the 100 point scale may still not be useful, as it doesn't account for the fact that some content may be not as challenging or as in-depth as other content. The scoring stipulations of the 0.0 to 4.0 scale take into account the level of complexity of the content and the target.

Heflebower (2001) breaks down the meaning of each of the values on the 4.0 scale. The scale starts at zero and counts by 0.5 until it reaches 4.0. A 4.0 refers to a student who has understood very complex content, the student is able to compare and contrast, analyze, and assess. 3.0 is the target objective, meaning students were able to describe, give examples, and demonstrate understanding of the topic at hand. 2.0 refers to a mastery of simpler content, such as recalling specific terminology, knowing certain details, memorizing information, etc. The scores below this demonstrate that the student has major errors and misunderstandings in their learning. 1.0 means the student can be somewhat successful with help. 0.0 means that even with help the student was not successful. Any of the decimal points between values indicate student understanding is part way between the whole numbers.

This 4.0 scale can also be converted to an A through F grading scale through a scale if that is what is required by the district. The numbers are more useful for students to see so Heflebower (2001) recommends keeping them in the gradebook. However when it comes to determining the final grade for the student, that number can be converted into a letter using the conversion chart.

In addition to the 4.0 scale, Heflebower (2001) also recommends assessment options are expanded so that all students can be successful. Heflebower (2001) lists three different examples of assessment options. The first of which, probing discussions, is when a teacher meets with a student and questions him or her about a topic. The teacher asks the student questions that
involves levels 2.0, 3.0, and 4.0 content. At the end of proving the teacher is able to determine the student’s level of proficiency simply based on their conversation. The second method is unobtrusive assessments, when a teacher assess a student at a moment that student may not even be aware of being assessed. For example, a teacher may observe a student completing a lab assignment from a distance and give the student a score watching their skills in action. The third recommendation is student graded assessments, which are perhaps the most important and powerful form of assessment that a teacher can make available (Heflebower, 2001). For this type of assessment, the student approaches a teacher and proposes what he or she will do to exhibit a specific level of performance and proficiency.

The final recommendation that Heflebower (2001) makes is to allow students to continually update their scores on previous measurement topics. This is probably the most transformational recommendation that can influence student success when it comes to grading. Teacher should allow students to upgrade their scores from previous grading assignments at any time. Time can even be a lot of during the quarter for students to make up and relearn work from previous units.

**Mastery Learning**

Achieving learning standards is at the top of the priority list for current educational philosophy and is an agreed-upon goal. The recent focus has been on teacher assessment practices benefiting student learning. Gentile (2009) focuses on how to grade student work and assess students in order to assure student mastery of content. First, it is obvious that students do not always remember everything that they have been taught or appeared to have mastered. It is useful to remember that overlearning, or learning something again after you seemingly have already learned it, is a much quicker process than learning it the first time. However, if in a
classroom a teacher is teaching a problem regarding prerequisite knowledge, students who had previously mastered it will be successful and pick up on the acceleration of the content the second time while students who never mastered that content will continue to fall farther and farther behind. Mastery learning addresses knowing where each student is in their learning and ensuring that students have mastered the most important standards. If students have mastered the original learning to adequate mastery, the relearning process will continue to be quicker and more efficient. However when student learning is inadequate, they have never mastered the previous content, it will plateau at about 30% of the amount of material that should be learned even after multiple times of relearning content. Gentile (2009) notes that despite whatever else is taught in each course, educators need to assure that each student masters those course fundamentals as a criteria for passing that grade. If not, students and educators will be in an endless cycle of trying to relearn something they have never mastered.

Mastery learning assumes that each student achieves a pre-established level of performance on a specific objective in a criterion-referenced manner, in other words without regard to how well others in the class are doing. Programs for mastery learning that are successful have two key components, first they identify significant mastery objectives in terms of their necessity as prerequisites for learning. Secondly, they provide enrichment objectives for students to go beyond initial mastery to expand or apply their knowledge and ways to continue to challenge these students. In order for these two steps to be accomplished, assessments and grading must be criterion-referenced, each student's performance should be interpreted relative to established instructional goals and standards.

However, Mastery Grading as twostep process sounds fairly simple, Gentile (2009) notes that schools that try to implement mastery learning often making number of fatal errors, the first
of which is demonstrating mastery is conceptualized as the endpoint rather than the initial phase of learning. Secondly, mastery testing activities are limited to the knowledge and comprehension end of thinking. Third, there is no requirement or grading incentive for going beyond mastery for students that master standards early and require enrichment. Fourth, assessment of student achievement remains embedded in a competitive or norm-referenced grading system as opposed to criterion-referenced. Based on the research, Gentile (2009) proposes four ways to incorporate good mastery learning avoid these pitfalls.

The first step is clearly stated in published objectives, sequence to facilitate transfer of prior learning to current and future competencies. The purpose is to be explicit about the fundamentals. Educators should do this by identifying and publishing for students, parents, colleagues, etc. the most fundamental objective and explicitly note that mastery of those objectives is required for passing the course. The second step is the standard for passing mastery test must be sufficiently high to assure the initial learning has taken place. Once forgotten, as is unavoidable, material can be relearned very quickly. Students need to clear goal of what mastery looks like so they can shoot for it and teachers need to be clear about communicating what will be successful in the terms of students. Gentile (2009) suggest teachers using a 75% or better to note student mastery.

Third, multiple and parallel forms a criterion-referenced test, with corrective exercises and retesting opportunities are required to demonstrate in the show mastery. Each test should include multiple mastery objectives, with multiple questions for each objective and sorted at random. Teachers that need to provide opportunities for students to apply their knowledge and retest each standard if necessary. However prior to retesting, remedial exercises are necessary for students, including re-teaching, more examples, peer tutoring, etc. for students who need extra
practice. The teacher then needs have a written parallel form of the assessment for students who would like an opportunity to retest their knowledge on the material.

Finally, while students are taking the time to relearn and remaster content, teachers need grading incentives to encourage students who have already reached mastery to go beyond initial mastery and develop fluency with the material, better organization and application of content, or knowledge of how to teach it to others. Passing a mastery test is often conceived as a benchmark or an endpoint for learning and earns a very high grade for that unit. Instead, Gentile (2009) suggested initial mastery must be considered and discern only the lowest passing grade for that unit. Higher grades are reserved for students who are able to go beyond mastery and demonstrate fluency of material with inability to apply it. This is where enrichment objectives come into play, the fundamentals that are not easily tested but may be considered optional for students who are able to complete them. Enrichment can take many different forms including conducting an experiment, analyzing data, composing or creating a story or poem, doing critical reviews of literature, etc.

Rubrics are and have been for quite some time a major theme in education today. Educators often try to create rubrics for everything students do, writing, reading, art, math, science, projects, etc. However, when it comes to a focus on standards-based grading, a number of studies by Wormeli (2015) show that the way educators think of grading with rubrics needs to alter. Some of the habits for creating rubrics are actually making standards based grading of these projects invalid. Research has shown that standards-based grading is better than traditional grading, but in order to use rubrics and grading in an evidence driven way, teachers need to learn how to switch their style.
In standards based grading, actions and responses are consistently matched with either mastery or some level of approaching mastery of a standard. Common words used in rubric such as emergent, developing, proficient, or mastery have different meanings to different teachers. It needs to be determined how teachers each identify student success levels and define these terms in their rubrics. What is robust to one teacher it superficial to another. Wormeli (2015) shows that conversations about what mastery looks like need to happen between teachers but these conversations need to take place between those who are actively teaching in that specific content. Only these educators know what success really looks like at that particular level and subject. Out of this study on the use of rubrics and standard based grading, Wormeli (2015) established a number of do's and don'ts when it comes to rubric use that teachers can immediately apply to their classrooms.

First, Wormeli (2015) suggests that the rubrics should have fewer levels. This increases the interrater reliability, the percent in which one teacher’s scoring is the same as another teacher’s scoring of the same level paper. With too many levels there is not enough clarity with what each level means as there are not enough words that mean slightly lesser degrees of each other to write clear descriptions. Thus in attempting to be more precise rubrics with many levels actually end up decreasing accuracy by claiming a precision in scoring that does not actually exist.

Secondly, this study suggests that the same domain should be referenced all the way through a portion of the rubric. For example if a rubric describe a student's level of strategic thinking in one descriptor, it must refer to different proficiencies and strategic thinking in all levels. It is not helpful to mention strategic thinking on one level and mention other areas of strength in other levels. Along the same lines, the evaluative criteria for each level should be
authentic to the learner’s experience. For instance, students are not asked to make novel applications of content and skills during the learning, they should not have to make these jumps on the assessment. If they are asked to do something on the assessment that they were not taught in class it is not really an assessment of what they have learned. This concept should be utilized for more than just rubrics too. Multiple choice, short answer questions, etc. should not attempt to address content and standards that were not part of the students’ curriculum.

For rolling out a strong rubric, Wormeli (2015) provides two points. First, the rubric should be test driven on real students before giving it to other students. This gives students a change to provide feedback on the rubric and explain what is unclear. It also allows the teacher to attempt to grade student work using that rubric. Testing first will clear up inconsistencies or points that are confusing in the working rubric. Nothing can be expected to be perfect the first time, especially without a prototype. Additionally, to increase clarity, exemplars should be provided for each level of the rubric. Students and parents need to know what constitutes each level of performance and how that is demonstrated in a student work. There should be no surprises with a rubric, it should be so clear that the student knows what grade they should expect when they turn the assignment in.

In fact, an even more fruitful experience can be to ask students to design the evaluative criteria and rubric themselves. This is a great exercise and helps students to consider what is most important in the project. Ask them as a class to design the rubric to be used for the project underway. The class can the brainstorm what needs to be included in the rubric and be pushed to deeper thinking about differentiating between scores (Wormeli, 2015).

Furthermore, teachers fall into the trap of creating multiple rubric for the same project if multiple project options are provided to students. This should not be. In standards-based grading,
no matter what outlet students choose to demonstrate their learning, the same learning standards should be demonstrated. Whether it is a project, assessment, or presentation the rubric should be standards-based. If we are grading on student understanding while allowing them to choose their outlet of preference, the rubric should include content standards. It should not address specifics about presence during the presentation or construction of a PowerPoint for example. All students, no matter what project option they choose, should be able to reference the same rubric.

Furthermore, Wormeli (2015) mentions a number of Don’ts based on the research of rubrics in classrooms using standards-based grading. First, teachers should never use average, above-average, or below-average for descriptors at any level or at any time. The rubric is not used to compare one student to another in the class. It is used to compare one student to their success mastering the learning standards. Whether or not a student is average or above-average inform them of how well they have mastered the content. Secondly, teachers should not write out every level of descriptors. For students in their busy, selectively attentive lives, this is not helpful and tends to cause them to be overwhelmed and ignored the whole rubric, thus decreasing its value. Third, teachers should not let reports of compliance distort reports of learning. Hopeful rubrics do not denote what students did or how much effort they put in. It should simply report what was learned through completing the project. This should be supported in the rubric. Fourth and finally, teachers should not get tied up in the math around the rubric. A common misconception is that by adding numbers and values to the stages of the rubric you are adding credibility. In actuality, Wormeli (2015) shows that this disrupts the credibility. It forces the levels of the rubric to be related to letter grades that they do not necessarily aligned with.
Determining and Communicating Standards of Success

One of the challenges of education switching to a standards-based grading method is how to change how progress reports look to communicate standards effectively to parents and students. Welsh (2013) suggests some of the benefits, drawbacks, and effects on standardized testing when using standards-based progress reports for grades. In general, the study argues that standards-based progress reports may help to increase teacher familiarity with state standards, encourage teachers to exclude non-academic factors from grades, and improve communication with parents. This study seeks to address whether or not the benefits of these progress reports will be evident as correlations between standards-based grades and student scores on tests.

The study was completed in 125 classrooms in 11 schools in a single district. Data was collected on students in grades 3rd and 5th over the course of two years. It also examined the practices of 37 of those teachers to determine if there is an association between teacher style and convergence rates of test scores. The group used various measures, including grade and standards-based breakdown, teaching methods, information from the teacher interviews, and test scores to examine if standards-based grades are good predictors of scores on a standard based assessment (Welsh, 2013). In order to participate in the study, teachers had to attempt to follow the four steps that are necessary write accurate standard base progress reports. First, the learning goals at the fine what students will know and do must be articulated clearly. Second, the student performance indicators of each school must be stated. Furthermore, teachers need to define graduate steps in performing that indicate a student's development on multiple levels. Finally, the actual reporting devices and form it must be created to communicate effectively and clearly to parents and students.

If teachers are assessing student progress on precise goals or objectives, they will be more likely to focus their instruction on those objectives as well and therefore should expect to
see an increase in their scores on state assessments. Furthermore the benefits should play out as a correlation between grades, since their standard based grading method claims to assess student standards throughout the entire year. One of the benefits of the standard based grading progress reports is that they communicate specifics about student achievement to teachers, students and parents, thus helping teachers to differentiate between progress, process, and quality of student work. Focusing on standards encourages teachers to focus on student mastery of those standards during the year and also to have a better understanding of where their students are at any given moment in the year.

Many past studies have found a moderate association between class grades and test scores. Often the discrepancies are attributed to teachers putting non-academic factors into students’ grades, such as effort, participation, etc. Many studies surmise that as teachers eliminate non-academic factors from grades, student test scores will correlate much more strongly to grades. However, Welsh (2013) results show otherwise. This studies results show only a week to moderate correspondence between test scores and standard based report card grades. These correlations were most weekly related in writing, the subject gauged solely by constructed response items. Math teachers had a better prediction of test scores based on standards based grades, likely due to the clearer meeting of defined performance standards. Additionally, teachers appeared to grade less rigorously in their classrooms than the test did in reading and writing and more rigorously in mathematics. It can thus be implied and that the subject being studied greatly impacts the test to grade convergence. 34% of the variation in rigor estimates is attributed to the subjects studied and 20.7% of the variance in correlations is due to the subject. Furthermore, teacher style had very little effect on test grade convergence, indicating that there are other significant factors at play.
As a result, only a moderate association between standard-based progress report card grades and state test scores can be assumed. One potential argument for this moderate relationship is that teachers interpret the same objective quite differently and furthermore experienced difficulty in coming to a consensus about the meaning of student mastery of an objective. Additionally, standard based grading stresses the importance of gathering multiple sources of information before making judgments about student understanding, which state test do not have an opportunity to do. Also, grades capture different aspects of student performance than the test. Standards-based progress reports can help to examine the connection between teacher grades and state test scores because teachers are reading on the same educational objectives the state test was designed to measure. However, teacher ratings do not necessarily address the same skills or the same level of skills. Teachers may have different standards that they choose to grade students on that another teacher in there same grade level or contact. Additionally, they tend to rank meeting a standard differently. Though the moderate convergence rates may indicate the standard based grading has limitations, it helps improve consistency in grading practices, and calls for further research to be done before this claim can be made (Welsh, 2013).

There were a number of limitations associated with the study. First, because the teachers in the study worked with relatively high-performing students, it is predictable that they would have more knowledge and how to distinguish students at the upper end. To better improve the results of the study, it should be done across multiple socioeconomic levels and include further diversity. Furthermore, many of the state test have traditionally only included 50% of the material in the standards.

A particularly necessary part of mastery grading and standards-based learning is deciding what the teacher wants students to learn. And even more challenging than what they learn,
meaning standards and content, is how the learning happens. One of the most significant misconceptions about standard based grading is that students have learned because they scored well on the assessment created to judge students learning of a particular content standard. However, in our current society and educational system, students are experienced at memorizing information quickly, cramming it into their minds the day before the test, and spewing it out on the assessment. To add to the issue, teachers are excellent at giving students pieces of information to memorize, teaching to the test rather than to the content, and requiring students to spew out information without thinking and reasoning through that information. As a result, one related aspect to standard based grading is considering how students should learn the content in terms of mastery learning and depth of understanding. Rick Wormeli, one of the educators heading up the current standard based grading movement, speaks to the importance of making students active creators as opposed to passive consumers. The implications of this switch in mindset and teaching method are vast, because through either method, students as passive or active learners, students may appear successful in the mastery grading system whether or not any significant learning is taking place. However, the goal of standard based grading is to actually have students learn content through making grades and re-mastery opportunities meaningful for students. This cannot happen if teachers have not satisfied the act of changing their students from passive consumers to active creators.

Wormeli (2015) points out that the root origin of the word education is *educere* meaning to care for, nourish, and cause to grow. Thus, anything called education that involves merely dumping knowledge of students is not actually education. Learning is far more than listening and parroting information back to a teacher. In fact, studies show that very little is retained with students in their long-term memory bank if it has simply been memorized. The only way to
retain information is for students to construct their own knowledge and make their own
connections around information. For instance, in a science classroom, are students actually
creating science? Or are they just hearing something and performing that back to the teacher?

Wormeli (2015) notes the difference between affirming that students know the specific
classroom standards. Students may cite the five freedoms protected in the first amendment. They
may multiply numbers written in scientific notation. And the list goes on. Students record this
information in a notebook but never count it as successful learning in their minds.

Wormeli (2015) suggests the best remedy for this is a process referred to as “teaching by
phenomenon”. At its core, this method refers to more project-based learning, integrated learning,
and inquiry method learning across curriculum and subjects. Teaching by phenomenon provide
students with more opportunities for true creation of their own learning and connections rather
than simply listening and repeating the teacher’s knowledge. The second key to teach by
phenomenon is to require students to be familiar with cross-content knowledge, meaning
students should not go to science and learn purely science. Students should be able to see and
explain how various contents connect. Finland, whose educational system is most often
compared to America’s, no longer teaches by subjects. They have taken this phenomenon
teaching idea seriously and thus combine different skills to teach a broad topic. For example, a
single lesson may contain geology, geography, and languages with a prompt such as asking
students to identify various countries, discuss their climates, and perform the entire lesson all in
French.

These ideas are not foreign to the United States educational system. Common core
standards have been moving in this direction, calling for increased emphasis on flexible
applications of learning rather than just knowledge storing. Teachers struggle to develop the
questions with which to use the class to discuss phenomenon and could benefit from further educational research. Teachers need to prevent themselves from dumping their own knowledge on students and rather challenge themselves to allow students to reason it out in their own way.

Wormeli (2015) notes an important implication of this mindset switch. Educators tend to think of their roles as helping students find their true voice and talents. However, the implication is that both the student’s voice and talent are already there, fully formed, and just buried under their own unproductive activities and insecurity and educators need to call them out of the student. However Wormeli (2015) shows that these are merely assumptions. Rather, educators should change their mindset to emphasize creation, not consumption, in their classroom as an outlet for students to discover on their own what is meaningful. Ask the student to question rather than providing them with an answer immediately. As is well documented in literature, the best way to learn how to do things is to simply do them. Teachers should focus on helping students be able to create something new in order to learn.

Though this study provides practical evidence on changing classroom learning to be more meaningful for students, it lacks an evidence-based approach. These are conclusions based on what is seen in educational systems, both in America and abroad, as well as observations of an individual teacher in their own classroom and school. However, no quantitative evidence was collected to support the study and findings. Additionally, the sample set of research is small, limited to a single school district or two. To further understand this topic and type of research-knowledge base in the future, educators should dive deeper into Wormeli’s ideas. Further research should strive to create quantitative studies across various groups of students to affirm the validity and get specifics for various levels of education and subjects.
Rundquist (2012) discusses implementing standards-based grading in an advanced physics classroom of only nine students. The goal was to create assessments that allowed for the student’s voice to be heard. This meant the creation of very unusual assessments. As opposed to the traditional pen paper assessment for physics, this class, with the exception of the final exam, relied on interactive and student voice assessments. These types of assessments included collaborative oral assessments, pan cast, screencasts, and in-person assessments.

Rundquist (2012) discusses the value of assessing students’ final understanding of the content rather than averaging their progression of understanding the content throughout the class. This means that a student can take an assessment as many times as they would like to. However, this also means that a student needs to retain knowledge of previous standards, because as they are assessed again those new grades will replace the students’ current grade, meaning the grade could go up or down based on student retention of the standard. If standards determine student grades, much consideration has to be given to creating the standards. Standards should be based on and linked to any state standards for the course, however they should be edited by the teacher to create very tangible standards for students. Rundquist (2012) recommends each standard start with an “I can” statement and a course contain about 30 standards as a whole.

To complete mastery grading, Rundquist (2012) recommends the 4 point scale. Each student gets a score of 1 through 4 based on their success on a particular standard assessment. The scores range from 1. Doesn't meet expectations 2. Approaches expectations 3. Meets expectations and 4. Exceeds expectations. Essentially a 3 is given to a student who simply answers the question while a 4 is reserved for a student who does an exceptional job on that assessment. In this course, no homework, projects, etc. were graded. The grade was solely calculated based on the 4 point scale for the voiced assessments of the students.
The goal of this student voice physics course was to add voice to every standard assessment the students would be taken. There were three major ways the students accomplished this: oral assessments in class, screencasts, and pencasts (Rundquist, 2012).

Oral assessments composed of class time where students were randomly selected to do an assessment of a random active standard (a standard that had previously been taught in the curriculum) on the front white board. When the student finished, the rest of the students would discuss what grade on the 4-point scale this person would receive. Student feedback was honest and useful, in part because the students understood that every assessment with low stakes and could be redone later with another assessment for the grade.

The second method of providing student voice we're screencasts, representing the bulk of the assessments turned in by the students. A student would write their answer to the problem and then upload it to a computer. Using the program Jing, the student could record their voice discussing the reasons why they completed each step as they solved the problem (Rundquist, 2012). This was especially useful in this course because students were required to create code on Mathematica. While it is incredibly easy for a student to copy someone else's code, they rather had to record themselves creating each step of code and explain why they completed it.

The third method that was used to include student voice and assessment was the use of pencast, making use of classroom technology such as LiveScribe, SmartPen, and tablets. Students were able to record their voice while writing on paper. The result was a document the can be viewed from your computer that allows a teacher to skip ahead to various parts of the discussion. This was especially authentic when students were required to do a derivation. All derivations are fundamental aspects of these physics courses, all correct answers are easily accessible in the book, notes, or the internet. Therefore asking students to complete a derivation
on a homework assignment is just asking them to copy and not understand. However using pencast, students would all have the correct derivation written on their paper, as they had access to the exact process. However, the teacher could grade the student more on their explanation of why each step occurred and what was happening and each step. This allowed the teacher to grade student on the 4-point scale based on the depth of understanding of the derivation. This has implications beyond derivations for any type of problem that students would see exactly represented in their notes and copy that format without truly understanding where the quality of information is coming from and why each step needs to take place (Rundquist, 2012).

In addition to adding student voice two assessment, Rundquist (2012) also abided by four principles to enhance this grading system. First, having a small class, the standards were created collectively with the teacher and the students. This means students more invested in the process and brought about conversations about fairness, importance, and difficulty of various standards. Students were able to provide input on the standards and thus had a depth of understanding of them. Secondly, the teacher abided by a strict no extra credit policy. Rundquist (2012) states that extra credit projects ask students to make projects on material they already understand to make up for low scores on material that they never grasped. This is not helping the students to improve their learning. Rather than extra credit, students now have to convince the instructor that they understand the content. They are never given a deadline on this and so can always ask for a reassessment. This is the third step, students can always reassess a lower score. However, the oral assessment days were randomly selected and therefore students could have a score lowered based on not retaining information they were asked to present on an oral assessment day. So while reassessments are valuable, they could cause students grades to go up or down based on
how well students proved they understand the content, including mastery of the content and retention.

There are significant implications for being able to hear the student’s voice through their work. This is a much more genuine approach to seeing what students understand about the content material for the class. It allows the teacher to have deeper insight into student understanding of the material. Additionally it allows students to dive deeper into the material and understand the why and the how behind the process of solving and, ensuring that students are not simply copying problems and steps without depth of understanding.

However, with this system Rundquist (2012) addresses a number of pitfalls. First, the system is incredibly different from what students are used to in all their years of education. It requires a significant amount of discussion early on in the class to explain the system. Even more importantly, it requires that students buy into the system as something that can help them in their learning. Students have to be passionate about the system in order for it to be successful for them. The second major pitfall is that grading time is substantial. With students submitting videos and recordings of their assignment completion, it takes quite a bit of time for the teacher to watch these and assess student understanding based on them. Furthermore, with re-assessments, a teacher could be watching any number of assignments for each standard based on how many the student chooses to turn in. Third, the system allows for students to turn in materials whenever they wish, with very little deadline. The natural problem with this is that some students developed extreme procrastination, meaning they also received very little feedback on their work. Additionally, much work was rushed at the end by these procrastinators and not fully understood. Rundquist (2012) suggests a method of addressing this in the future.

The thought is that students must turn something in within 2 weeks of a standard going live or
the student receives a zero without any chance of mastery. This ensures that students will at least put an effort into getting something turned in by a date. This also help students to understand the importance of deadlines, while giving them as much time as they'd like to remaster previous assessments.

Standards-based grading has been studied fairly substantially at the k-12 level, though little research has been done in the University context. Beatty (2013) used standards-based grading in two successive courses of introductory physics at the college level. Throughout these courses, a survey was given to the students to respond to various aspects and basic intent of the elements in the course. Beatty (2013) then synthesized these student responses to the surveys to develop some significant implications of standards-based grading specifically for the University level but that also span all grades.

In ideal standards-based grading, a student scoring any particular standard indicates how well that student has mastered the standard at that particular point in time. This score may increase over time as the student demonstrates an increase in understanding of the standard or skill. Similarly, the score may decrease over time if the student provides evidence of not retaining their knowledge of that standard or skill. A student's score at any moment in time provides a real-time snapshot of their understanding of the various skills taught in the class. The second foundational aspect of standards-based grading is that students are permitted to remedy deficiencies in their learning when an assessment reveals them through a retake.

Beatty (2013) used standards-based grading in the first semester of an introductory college physics course. Students were given a survey and asked to provide feedback both at the middle of the course and at the end. Relevant changes were made prior to the second semester
course based on this student survey. Students then in the second semester were also given a survey halfway through and at the completion of the semester.

Based on student feedback from the first semester, Beatty (2013) made six primary changes to the course. First, fewer, broader learning standards or adapted. Only 25 standards now we're present in the course between the lecture and the lab. Secondly, large online homework assignments or replaced with much smaller assignments with more challenging questions and turned it on paper. These were given back to students with written feedback but no grade. Third, the course was split into two exams, a midterm and final. Fourth, students could retake each exam twice. Fifth, the exams provided the one and only score for each standard. Sixth, a brutally strict attendance policy was established where students needed to be in attendance in order to retake any exam.

As a result of the changes made to the second physics course, some general results we retained. First, many but not all students likes the standards-based grading approach. Of 32 responses, 20 chose “I really like it”, 6 chose “I like it”, 1 chose “I really dislike it”, and the other 5 were in between. Furthermore, despite generally liking the freedom of homework not being graded, students reported a difficulty of self-motivating themselves to complete work that was not graded. Having one midterm and one final gave students very little knowledge of where they were at any one moment in the course content mastery. However, also surprisingly, students claim that the prospect of reassessment on a midterm or final did not impact how well they prepared for the initial exam.

Beatty (2013) also notes a number of difficulties the students had adjusting to the new system. One was operationalizing the standards, students were unclear of what the standard required of them and whether or not they had met the standard in their own understanding of
content. As an adjustment, Beatty (2013) suggests making a point of linking standards to specific textbook sections or specific notes sections or listing example problems that correlate to each standard. Another difficulty arose from complaints involving interpreting the 4-grade mastery scale. Students were unclear of what the expectations were to get a 4 or a 3. Additionally, students asked for more partials in the system like a 2.5 or a 3.25. Often, students also needed more than feedback on specific standards are topics; they needed an overall assessment of how well they were doing in the course and what sort of grid they were headed towards earlier than taking midterm exam. As a result of this, Beatty (2013) suggests offering multiple smaller assessments throughout the course rather than limiting assessment to the mid-term and the final exam.

There are some serious implications to the positive effects of standards-based grading can have. However in getting to that process Beatty (2013) notes three fundamental tensions that need to be work through. The first is reassessment, the heart of standards-based grading. Effective reassessment is the most difficult aspect of standards-based grading implement and to get right, but also the most crucial. Reassessment takes time, requires for you to be very intentional about how standards are sorted, and requires that students have a way to learn effectively to prove that they really have remastered the content. The second tension arises from the choice of learning standards for a course. It is incredibly significant that students understand what each standard is asking them to do and clearly know what type of question would be associated with each standard. Larger standards should be developed, about 25 for a course, rather than very specific standards that will get confusing both for the teacher and the student to sort by. A third and unavoidable tension in standards-based grading is that grades only report the mastery of learning objectives. This opens the door for the unavoidable fact that many students
will not complete homework, attend lab meetings, or otherwise put in much of the required work without the carrot-and-stick of points in grades.

As a final conclusion, this study stating the tensions of standards-based grading and areas for further research also suggests six implications based on this research. First, assessments should be developed before or with standards. It is too difficult to establish standards and try to then make an assessment. Secondly, attention needs to be given to the weighting of topics. Be sure that one standard is not receiving a higher rating than another standard thread being tested multiple times. Third, standards need to be included for crosscutting skills. Many questions in physics include concepts associated with multiple standards. The simplest example is that any particular question could the wrong for the reason of the student missing the content, or a student miss-labeling units, or a student being unfamiliar with the mathematics involved in solving that problem. The difference needs to be addressed through crosscutting standards associated with each question. Fourth, standards need to be named usefully and intentionally if they are to communicate to our students. Fifth, reassessments need to be efficient. Sixth, it is better to give shorter quizzes frequently throughout the class that are lower stakes as opposed to a single midterm and final. Seventh, the instructor should schedule a regular assessment time. Eighth, standards should be linked to instruction, whether that's linking to the notes, textbook, sample problems or all of the above. Ninth, catch up time should be built right into the syllabus for students. Tenth, grades should not be over emphasized two students, as standards-based grading emphasizes mastery over grading. Eleventh, students should be required to qualify for reassessment. This is an excellent method of getting students to be present for labs and class and complete their homework while not assigning grades to the students on these aspects. The teacher can require relevant work to be completed to a high level of proficiency in order to
qualify student for reassessment on a standard. Two additional benefits of this is the stress on the link being homework and assessment success by the educator and the reduction in the number of ‘Hail Mary’ attempts at reassessments by students.

In summary, there is still much research to be done on standards based grading as it pertains to the university level. There is also room for further research as standards based grading pertains to science classrooms, particularly the laboratory components them. Should experimental standards, such as creating hypotheses, collecting data, finding trends, etc. be linked to student mastery and have a standard associated with them?

Feedback to Enhance Depth of Learning

Feedback is central to effective learning and encouraging students to learn all aspects of the content. Carless (2007) examines the notion of written feedback on assessments and argues that the feedback process is far more complex than it is sometimes acknowledged. The concepts of feedback can be framed by three concepts, discourse, power and emotion. Given that feedback is central to learning, effective comments on students’ work represent only one key characteristic of quality teaching and student learning. Feedback plays a decisive role in learning and development, within and beyond formal education. It is well established that people learn faster and more effectively when they have a clear sense of what they are doing well and what specifically needs to be improved, and even more importantly how to improve it.

Students are often dissatisfied with the feedback they receive, whether it is lacking specific advice to improve, difficult to interpret, or has potentially negative connotations or effects of a student (Carless, 2007). Feedback can take on multiple purposes, whether it be advice for improvement of the current assignment, advice for improvement of future assignments, explaining or justifying why a specific grade was given, or an act of the teacher
demonstrating characteristics such as expertise, authority, etc. Teachers and tutors may not be fully aware of the power of feedback or even the purpose of it being enacted.

Carless (2007) states that unpacking feedback and students’ response to feedback requires that one look at three interlocking components: discourse, power, and emotion. Discourse is referring to the language in which the teacher comments are encoded on the assignment. This is not useful if academic discourse to the student includes language that the student may not have full access to, thus unwittingly exerting power over students. Power, the second trait is a student’s perception that the instructor is simply in a power struggle as they tear the student’s work apart. Students can be discouraged and lose respect for the grading system. There is a danger that a teacher's feedback can include language that is simply too final, making students feel that that is who they are and not something that they can recover from. Lastly, the assessment process is deeply emotional. Students invest themselves and their time greatly in assessment tasks and the response of the teacher to the student’s work interacts with the student on an emotional level. As a result of these three aspects working together: discourse, power, and emotion, feedback is a deeply social process and it is significant how the teacher message is interpreted by the student.

Carless (2007) collected data for this study within the context of higher education at 8 universities in Hong Kong. Surveys were given to these universities including 460 staff and 1740 students specifically addressing the issues of feedback. Two focus groups were interviewed as well.

The finding of the study showed two major themes. The first is that students and to some extent teachers perceive that lack of useful feedback is a problem in the assessment process. Furthermore, teachers tend to believe that their feedback is more useful than the students do.
Secondly, a reoccurring finding of the surveys is that students have a different perspective than staff on elements of the assessment and feedback process. Four different perceptions were identified: the amount of detail of feedback, the usefulness of feedback, the extent to which students are only interested in grades, and the fairness of marking procedures. These four perceptions represent a key challenge to enhancing assessment and feedback practices. When it comes to feedback, educators and students have different positions, rules, and aims. Since Carless (2007) has established that teachers and students are on different wavelengths, the study recommends a process of assessment dialogue between teachers and students.

Assessment dialogue refers to discussions related to the assessment process as a general concept, but not related to the specifics of the subject matter or what students need to do for a particular assignment. These provide a method for teachers and students to communicate and clear up misconceptions between them related to assessments and feedback. Given the significance of assessments on learning, students need to engage with the assessment process in the same way as they learn about the subject content. Assessment dialogues can encourage students to clarify the rules of the game in the assumptions known by the educator but not transparent to the student. Thus, demystifying the assessment process can make a contribution to student progress and understanding. It is important for students to understand where their grades come from and this can be done by clarifying the assessment process (Carless, 2007).

Assessment dialogues do not need to be complicated. They may simply involve teachers being more explicit about assessment procedures and being more open to student questions. However, Carless (2007) notes the significant implications of this study, virtually showing the confusion of feedback and its purpose on assessment between students and teachers. Assessment, and as a direct result student grades, impact student success or failure in high school, the
university setting and beyond. Assessment is far too important for us to assume that students are on the same page as educators. Carless (2007) additionally found that students were very willing to discuss content on assessments and are concerned about this topic. Thus further research needs to be done into effective feedback for students and communication methods for educators.

The Power of Re-Assessments

There is much value in evaluating procedures you have used in the class and have been used as you were a student in the classroom. Often, we just teach with the same practices that we have seen as students ourselves than realizing that new findings point to even better methods of teaching. Dueck (2011) discusses the changes on assessment procedures in her own classroom, after being submerged in literature and discussions that changed her perspective on assessing and offering retests.

Often, teacher site that they do not have time to change the way they assess for two reasons. First, courses are very content heavy and thus little time can be allotted to retesting. Secondly, teachers struggle to know how to maintain an authentic measure of learning if everyone is just allowed to take a retest. If you change your perspective on testing from being a ‘got-cha’ moment for students to an inspirational one, both of these questions solve themselves. Dueck (2011) states she has found that at the beginning of a document students should be able to answer the question ‘where are we going?’ After an assessment they should be able to answer the question ‘where am I?’ That is referring to how much they know in regards to what they needed to know for the unit.

The most common and clearly defined place to start is addressing the question, ‘where are we going?’ this is where backwards planning comes in. All students should know where the class is headed when they start a new unit. The most effective way to show student learning is
through learning targets, what the student needed to be able to do during each unit. The four types of learning targets are knowledge targets, reasoning targets, still targets, and product targets. Each target can be written in a student-friendly manor using *I can* statements.

Knowledge targets are like trivial pursuit objectives, items that are significant that students need to memorize and know. Reasoning gets at a deeper level where students are asked to justify, determine, compare, etc. Product targets are easy to demonstrate and focus on what students need to do to demonstrate their understanding, such as create a graph or do a laboratory activity.

Though these learning targets are incredibly helpful, Dueck (2011) notes it is definitely more complicated than that. Students may know where they're going but they have no clue what it will look like when they reach it. Dueck (2011) interviewed a student who performed particularly poorly on a test after class and used that interview to create major changes to the assessment format.

The first change had to do with test structure. Dueck (2011) settled on separating sections by learning outcomes and major topics rather than separating my question (i.e. multiple choice, short answer, etc.). Secondly, the routine handing back tests changed as well. This time, when students went to review their assessment, they were given a student tracking sheet. This tracking sheet required students to write down the points they scored on each section, sorted by learning standard, and calculate the percentage score per section on their own. The last box in each section was where students could indicate whether they intended to retake that section based on their reflection. Additionally, students answered questions on the tracking sheet about their test preparation, study skills, and goal setting. By the end of this quick reflection, students had a graphic representation of their strengths and weaknesses on each learning outcome and the class was far more engaged than typically when handing back assessments.
This leads to the third major realization, the power of retesting. After having the test sorted by topic, students were able to select whether or not they wanted to retake the test section. Students were allowed to take only one section or they could retake multiple sections. Dueck (2011) found that struggling students gained confidence and this increased their study habits as they only needing to study for a single section. The struggling learner perceived it as easier and shorter and was willing to try. These students began to get a heightened level of confidence as they continued to increase their scores and understand content more clearly. Furthermore, from a teacher's perspective, it was an easy way to assess your own teaching methods. If all students did poorly on a particular topic, it would imply that the teacher needs to fix the delivery and methods for the following year.

In terms of retests, Dueck (2011) found they encouraged at-risk students to try harder and to gain confidence as they were able to see their grades increase. This study also found that the higher achievers were less likely to cheat because they knew they would be given a second chance on the assessment. Thus, a chance for retaking benefits all learners. Additionally, by examining test items and students’ performance, the teacher can determine whether students low test scores are based on a lack of student knowledge or related to question format. If a student scored very low in a single category and better in the others, it can be assumed that student needs to relearn the content from that section. However if a student did well on all short answer questions and poorly on all multiple choice in each standard section, that student needs to be taught some multiple choice taking strategies rather than retaught content.

Dueck (2011) offers some tips the convincing peers and hesitant students of the wisdom of retesting. When it comes to students, sometimes academically elite students object to retesting because it messes with the system that they have learned to work for them. In terms of
colleagues, educators know that retakes and sorting by standard is not the way that it is always been done and are sometimes hesitant to change. Remind educators to consider retests in real world examples. Challenge them to come up with an example in the real world that does not have a retesting component. Most occupations and professions allow employees chances to mess up and try again, this is a learning experience. Why should school be any different?

Part of the standards-based grading plan involves the opportunity for students to redo work and assessments for full credit. However, this practice tends to become demanding on teachers and has the potential for students to take advantage of the system, thus making standards based grading less beneficial than it should be. Through Rick Wormeli, one of the leaders behind standard based grading, much research has been done on standard based grading best practices. One of the challenges that arises with standard based grading, the difficulties of redoing assignments, is addressed in Wormeli (2016).

First of all, Wormeli (2016) reminds teachers that all redo work is done at the teacher’s own discretion. The study suggests that at the beginning of the year teachers have parents sign a form that outlines this protocol for assignment redos to be at the teacher's discretion. This gives the teacher freedom to determine if a student is taking advantage of the redo policy rather than using it for their own progress. For example, a student who boasts about not studying for the test the first time because they’re always allowed a reassessment or who clearly procrastinates on a large project could therefore be denied their redo by the teacher. Of course there are situations where a teacher may still allow a redo, but it is up to their best judgment. If it is a character issue with the student, such as integrity, discipline, or honesty, the student will learn more if the teacher denies the redo option and instead sits down and has a discussion with that student. This appeals to the point of standards-based grading allowing teachers to differentiate education for
each student. Additionally, if a teacher sees the same student redoing the assignments often within the same marking period, this allows the teacher an opportunity to have a conversation with that student and to deny them quite as many retakes, learning how to master the content the first time.

Along the same lines, Wormeli (2016) suggests asking the parents to sign the original assessment and request a redo from the teacher. This keeps communication open between the teacher and the parent as to what is going on in the classroom. It also prevents students from complacency on the first assessment for fear of bringing it home and having their parent see atrocious and blank work.

Furthermore, teachers should avoid the misconception that the redo assignment must look just like the original. A student who is interested in redoing a long assignment for a class should not go through the entire assignment again for a retake. Having too much on their plate will surely cause the student to fall behind in that particular class as well as the others and will not teach the student anything new if their low grade was the result of a minor misconception. Both the teacher and student should keep in mind that the progress is the goal, not the specific exact assignment completion. Therefore the teacher should present the student with another assignment that they can do that will address what they missed on the first project. As a result, it may only take the student 30 minutes to complete a long-term project and in the process have corrected their misconceptions from the project the first time.

A third practical tip from Wormeli (2016) is to guide students through completing and studying for the redo assessment. It is naturally going to be difficult for students to keep up with current work while they are also completing the work for the reassessment. The teacher should sit down with the student and create a calendar to guide that student through completing the work
for each day. Most importantly, this calendar should start from the deadline of the reassessment and work backwards, helping the student decide what needs to be done each day in order to be at the correct place with work following day. It is inappropriate to overwhelm students with their typical classwork in addition to reassessment work, and expect them to be able to manage this on their own. This is where the teacher should guide the student through creating a calendar, meaning a set date and time the redo work is submitted. Research suggests the week following the original assessment is a good deadline, of course that is not always the case.

Additionally, if a student earns a lower grade on the retake than they got on the original there are a couple of guidelines to follow. First, the teacher should reflect on their own materials, both those used to teach the class as well as those used to help guide the student to the reassessment. Be sure that this information is helpful and is not carrying its own misconceptions for the student. Furthermore, the teacher should choose the higher grade for the student even if that was not the score received on the last assessment. Even adults are most often rewarded for their best work not the average of their accomplishments.

Most adults are provided redo opportunities throughout their lives. A pilot for example can come around for a second landing. A surgeon may need to fix something that did not go as expected the first time. A movie director is always doing a 'take two' for those in the scene if it does not look excellent the first time. Of course adults don't need as many retakes as our students do, but Wormeli (2016) says this makes sense. Students are learning and growing and in the process would make many more mistakes. Students are not adults and can be afforded a more merciful attitude as we grow them and mature them into competent adults.
Chapter 3: Project

Inspiration

There are many instances when this compilation would be useful to science teachers. It is sometimes difficult to know where to start when it comes to standardizing an entire class and a gradebook, especially when this has not been the traditional practice in classrooms and schools recently. Additionally, many teachers struggle with the act of creating retake assignments for students that are fair and accurately assess student understanding of the topic they need to demonstrate mastery on. It takes a good portion of time to sit down prior to the course and break the many standards provided by New York State, the district, and one’s own expectations into a number of clear and concise standards that are easily accessible to students. Only when these standard categories have been developed can the teacher begin backwards planning with assessments that relate to each of the standards. This compilation provides a natural standards break up, associated with easily accessible standards for students for each topic in physics classroom.

Grades, when assigned based on achievement enable teachers to compare knowledge and skills of current and previous students. Furthermore, each of the tests provide extensive evidence of purposeful sorting and assignment of questions per each standard category. These categories provide accurate weights to the questions associated with each standard and ensure that each of the key understandings is addressed in the test. Much thought is given to each question to ensure that a student missing the question has a misconception or has not mastered the particular standard matched with that question. As a result, teachers will provide every student a grade for each of the standards examined on the test, thus giving each student 4 to 5 scores on the test rather than one overall score. With traditional grading methods, it would be a nightmare for teachers to provide four separate grades for questions spread throughout the test. For example,
questions 1, 4, 6, 7, and 9 of a test may be on standard one, questions 1, 5, 10, and 11 on another and so one. To combat this barrier, this compilation has matched each question with the standard it is associate with and inputs that information into an online testing data base. This internet-based program is used to collect students’ scores for each topic and print out a score sheet for students that has separate grades on it by standard rather than one final grade for the test. Teachers can use any number of programs for this, including Edoctrina, Illuminate, and Test Wizard.

Along with the test, retake assessments are also divided into standards and created with a slightly increased level of difficulty compared to the test. This ensures that if a student demonstrates mastery on a retake assignment, they fully understand the content associated with standard. Questions on the reassessment are different from the test, so that students who have previously taken a test on the standard do not have an advantage, but similar enough to test the same standard.

One of the main problems with standardized grading in a science classroom is figuring out how to standardize the lab assignments. The laboratory assignments provided in this compilation are intended to address significant standards of New York State associated with engineering and science practices. These separate standards include skills used in a hands-on laboratory, including mastery on items such as setting up data tables, CEI format, effective data collection, experiment set up, etc. This is useful for any teacher in a science classroom, as the similar standards apply across high School science classrooms. The laboratory standards can be adapted within whatever content is being addressed through keeping the lab format the same, including analysis questions, graphing, and creating tables, while altering the specific lab content
per science class. The standards will assess the student's ability to be successful in an exploratory lab context.

Module Design
Modules are designed with a variety of components to allow for a standards based classroom and understanding by design for a high school physics teacher. Each module includes a summary page outlining the unit as a whole, an identification of standards simplified for students with misconceptions, a traditional unit assessment, a retake assessment, student assessment feedback guide, a student self-reflection guide, a standards-based project, and a sample of a student gradebook segment. The following segments will break each of these categories down into their rationale and components.

Module Introduction and Standards
The introduction component of each module outlines some of the main activities involved in the unit as well as where the teacher should expect students to be in their current understanding prior to the unit based on experimental knowledge, and where the student can expect to be at the end of the unit. A summary also seeks to drive home the connections between the standards involved in the unit and the real world. Furthermore, the summary page outlines the general standards involved in the unit and identifies how those standards relate to and match up with the next generation science standards. Furthermore, this section identifies common misconceptions from research that students may have pertaining to the units standards. The goal of a summary pages except the teacher up for success as they prepare to launch into the materials of the current unit.
'Traditional’ Unit Assessment

Each module contains a traditional unit assessment. This follows a backward planning method by determining the assessment prior to the rest of the unit, and only after identifying standards and goals for the unit. The significance of this assessment is that it was created and edited with the standards for the unit in mind. Each question is linked to a particular standard and is intentional. Every question should be different in the knowledge and skills it tests, even if it is lined to the same standard as another question. In addition to the assessment included in the module is also a document matching each question to the standard that it is linked to. To make this assessment accessible to students and teachers and to help the scores per standard to make sense, a score sheet for a sample student is also included. The score sheet shows the students’ scores sorted by standard as well as the particular questions and concepts that the student missed. All this data has been generated through the program Edoctrina. Furthermore, a sample question associated with each standard is also included for the assessment to demonstrate how questions fit with each standard and the rationale behind that.

Retake Assessment

One of the most significant and unique criteria of standards-based grading is the concept of reassessments. As shown in the literature, students should be given the opportunity to reassess standards that they may have missed or not fully understood. Taking a reassessment and being successful on that reassessment shows that students have completely mastered the material. Reassessment are attached for each of the following modules and a line with each original assessment for the unit. However, reassessments are started by standard so that students can take only those standards which they had not mastered on the assessment the questions used for each
of the reassessment standards tends to be slightly different and more challenging than the original assessment, thus proving that students have mastered the material.

**Student Self-reflection Guide**

Following each unit assessment there is a student feedback guide allowing students to interact with their own scores. One of the basics of standards-based grading is making grades make sense to students. Through sorting student scores by standard, their assessment grade now can have meaning if students can focus in and reflect on the standard which they struggled the most on as evidenced by their assessment grade. Following the student feedback guide will allow students to not only interact with their score sheet but also identify some of their own misconceptions so that students know how to prep for a reassessment. Half the battle is getting students to know what they don't know so that they can address it and move forward. The guide for the student feedback it's all online for a program called Nearpod, thus allowing students to be able to complete the feedback guide at their own convenience and prior to taking a reassessment on a standard.

**Standards-based Project**

Each module also contains a standard based project. This project is intended to take place at the very end of the unit to coincide with the traditional unit assessment. The project serves as a summary and a connecting point for all standards in the unit as well as potentially standards from other units. While the traditional unit assessment is necessary to assess students’ knowledge and skills, the project allow students to demonstrate a depth of understanding of concepts along with their ability to apply these concepts to scientific phenomenon. The project actually gets at using science concepts to perform experiments and make conclusions, extending knowledge beyond a simple set of steps or memorization. Students will be assessed on their success at these summary
projects using the same standards as outlined in the rest of the module. The goal of the project will be for students to experience how each unit connects to the real world.

Sample Gradebook Segment

The end of each module includes what a sample gradebook segment may look like using standards-based grading. The gradebook segment should only include grades associated with standards. The gradebook this is a demonstration of students’ knowledge of the concepts included in a regents physics class. All grades are on a scale of one to four and each of those values correlates with a percentage to represent student’s depth of knowledge of each of the standards identified. It is student remasters a standard, that new grade will go into the grade book as a replacement for the standard grade they just remastered. Grades for standards can be associated with Labs, projects, assessments, and discussions.
# Module Kit #1: Mechanical Waves

<table>
<thead>
<tr>
<th><strong>Title:</strong></th>
<th>Unit 1: Mechanical Waves</th>
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<tbody>
<tr>
<td><strong>Source/website:</strong></td>
<td>Created by E. Carbone 9/1/19</td>
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## NYS Physics Standard:

### PS4.A: Wave Properties
- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)
- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2), (HSPS4-5)
- [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)
- (NYSED) The location and size of an image are related to the location and size of an object for a plane mirror. The location and size of an image (real or virtual) are related to the location and size of an object and the focal distance for convex and concave mirrors. (HS-PS4-6)

### PS4.B: Electromagnetic Radiation
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4)
- Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)

### PS4.C: Information Technologies and Instrumentation
- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)

## Supplies
- Mechanical Waves Standards one-pager
- List of standards paired with “I can” statements and standard codes
- Unit Test: Mechanical Waves (bubble sheet, test booklet, answer key, questions sorted by standard)
Summary:

This first unit is an excellent introduction for students to some of the more conceptual topics in high school physics. As a part of this unit, students will explore the motion of waves, various components of waves such as frequency and period, as well as the various type of waves, such as mechanical, electromagnetic, transverse, and longitudinal. Lab activities such as a motion of waves lab with a slinky, a standing waves lab with string, speed of sound lab with tuning forks, build your own telescope, and build your own solar power car. Students will end the unit with a music project in which they will create their own musical instrument from recycled materials. The applications of sound and light waves in our current world of science will be stressed in addition to the notion that waves only transfer energy, not matter.

This topic is incredibly relevant in the science world currently and is growing quickly. Thus, in addition to teaching the standards listed here as part of the regents and NGSS curriculum, I am also interested in introducing my students to something that is particularly relevant in their lives. Students rely on waves all the time. Waves account for Wi-Fi, texting, social media, Netflix, and so many more things that this current generation enjoys. Introducing them to how these devices they use every day work could be not only eye opening but also gripping for student who may not have been interested in science before. Furthermore, there are many career options in optics and waves for students that I would love for them to explore further as many of them probably did not even realize that they huge field existed.

The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standards: Mechanical Waves</th>
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<tbody>
<tr>
<td>Standard:</td>
</tr>
<tr>
<td>MW1</td>
</tr>
<tr>
<td>MW2</td>
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</tbody>
</table>
Possible Misconceptions:

Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery of mechanical waves that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from *New York Science Teacher: Physics Misconceptions*, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.

### Standards: Mechanical Waves

<table>
<thead>
<tr>
<th>Standard</th>
<th>Topic</th>
<th>Possible Common Misconceptions:</th>
</tr>
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</table>
| MW1      | Simple Harmonic Motion | - The effects of light are instantaneous. Light does not travel with a finite speed.  
- Gamma rays, x-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves are different entities.  
- The more mass in a pendulum bob, the faster it swings.  
- Hitting an object harder changes its pitch. |
| MW2      | Wave Characteristics | - When a wave moves through a medium, particles of the medium move along with the wave.  
- You can see and hear a distant event at the same moment.  
- In a telephone, actual sounds are carried through the wire rather than electrical pulses.  
- Sound moves faster in air than in solids because air is “thinner” and forms less of a barrier.  
- Sound moves between particles of matter (in empty space) rather than matter.  
- As waves move, matter moves along with them. |

| MW3 | Sound Waves | - Loudness and pitch of sounds are confused with each other.  
- In wind instruments, the instrument itself vibrates not the internal air column.  
- The pitch of a tuning fork will change as it “slows down,” or “runs” out of energy. |
| MW4 | Interference | - When two pulses, traveling in opposite directions along a spring or rope meet, they bounce off each other and go back in the opposite direction. |
Appendix of Supplemental Materials for Module Kit #1

Test for Module #1: Mechanical Waves

Multiple Choice:

1. Two wave sources operating in phase in the same medium produce the circular wave patterns shown in the diagram. The solid lines represent wave crests and the dashed lines represent wave troughs.

Which point is at a position of maximum destructive interference?


Questions 2 and 3: The graph below represents the displacement of a particle in a medium.

2. The amplitude of the wave is
   1. 4.0 s
   2. 6.0 s
   3. 8 cm
   4. 4 cm

3. The period of the wave is
   1. 1.0 s
   2. 2.0 s
   3. 4.0 s
   4. 6.0 s

4. A 256-hertz vibrating tuning fork is brought near a non-vibrating 256-hertz tuning fork. The second tuning fork begins to vibrate. Which phenomenon causes the non-vibrating tuning fork to begin to vibrate?

   1. resistance
   2. resonance
   3. refraction
   4. reflection

5. What is the wavelength of a 256-hertz sound wave in air at STP moving at 331 m/s?

   1. \(1.17 \times 10^6\) m
   2. 1.29 m
   3. 0.773 m
   4. \(8.53 \times 10^{-3}\) m

6. The diagram below represents a periodic wave traveling through a uniform medium.

If the frequency of the wave is 2.0 hertz, the speed of the wave is:

   1. 6.0 m/s
   2. 2.0 m/s
   3. 8.0 m/s
   4. 4.0 m/s

7. Which of the following waves represents transmission of a longitudinal wave?

   1. A ripple in a pond
   2. A trumpet playing a note.
   3. A child jumping up and down on a trampoline.
   4. Two students playing jump-rope.
8. A wave generator located 4.0 meters from a reflecting wall produces a standing wave in a string, as shown in the diagram below.

What is the wavelength of the standing wave?

1. 1.0 m
2. 3.0 m
3. 2.0 m
4. 4.0 m

9. The diagram below represents a transverse water wave propagating toward the left. A cork is floating on the water’s surface at point P.

In which direction will the cork move as the wave passes point P?

1. up, then down, then up
2. down, then up, then down
3. left, then right, then left
4. right, then left, then right

10. The sound wave produced by a trumpet has a frequency of 880 hertz. What is the distance between successive compressions in this sound wave as it travels through air at STP?

1. 0.0011 m
2. 0.38 m
3. 1.3 m
4. 2.91 x 10^-5 m

11. The diagram below shows a standing wave. Point A on the standing wave is

1. a node resulting from destructive interference
2. a node resulting from constructive interference
3. An antinode resulting from constructive interference
4. An antinode resulting from destructive interference

12. A duck bobs up and down in a lake 12 times in 36 seconds. What is the frequency of the duck’s motion?

1. 0.33 Hz
2. 1 Hz
3. 3.0 Hz
4. 3 Hz

13. A tuning fork vibrates at a frequency of 512 hertz when struck with a rubber hammer. The sound produced by the tuning fork will travel through the air as a

1. longitudinal wave with air molecules vibrating parallel to the direction of travel
2. transverse wave with air molecules vibrating parallel to the direction of travel
3. longitudinal wave with air molecules vibrating perpendicular to the direction of travel
4. transverse wave with air molecules vibrating perpendicular to the direction of travel
14. A pendulum takes 0.25 seconds to swing from point A to point B. What is the frequency of the pendulum’s oscillation?

1. 4 Hz
2. 0.5 Hz
3. 2.0 Hz
4. 0.25 Hz

The diagram below shows two sources, A and B, vibrating in phase in the same uniform medium and producing circular wave fronts.

15. Which phenomenon occurs at point P?

1. Destructive interference
2. Constructive interference
3. Reflection
4. Refraction

16. As the distance between wave crests in a lake increases, the wave experiences a

1. Period increase.
2. Velocity increase.
3. Frequency increase.
4. Wavelength decrease.

17. Which point on the wave is 90° out of phase with point P?

1. A
2. B
3. C
4. D

18. What is the period of a water wave if 4.0 complete waves pass a fixed point in 10 seconds?

1. 0.25 s
2. 0.40 s
3. 2.5 s
4. 4.0 s
19. The energy of this wave is related to its:
   1. Amplitude
   2. Speed
   3. Period
   4. Wavelength

20. Which two points are in phase?
   1. A & B
   2. B & D
   3. A & C
   4. A & E

21. As the wave moves to the right, it transfers
   1. mass
   2. energy
   3. mass and energy

22. Which diagram best represents the motion of the particle at position C as the wave moves to the right?
   1. 
   2. 
   3. 
   4. 

constructed Response on Next Page ➔
25. A dolphin uses specific sounds, called ‘clicks’ to communicate under water. A dolphin sends a 80 kHz click down through the ocean water. It bounces off the ocean floor 400 meters below the dolphin, bounces off a flat ocean bottom and returns to the dolphin as an echo 0.63 seconds after it was sent.

   a. Calculate the speed of the sound wave in the ocean water. [2]

   b. Calculate the distance between successive compressions of this sound wave in the ocean water. [2]

   c. How would increasing frequency change the sound produced? [1]

26. The sound wave produced by a trumpet has a frequency of 440 hertz. What is the distance between successive compressions in this sound wave as it travels through air at STP? [2]

27. A disgruntled physics student drops an egg of a window. The egg breaks on the ground 2.5s later.

   a. How high is the window? [2]

   b. How long after the egg has broken on the ground will the student hear it break assuming the air is at STP? [2]
**Constructed Response:** Write your work and answers on your separate answer sheet. For calculations, show all work in FSA format. Use complete sentences and proper grammar where appropriate.

23. The diagram below represents a periodic wave moving along a rope.

![Diagram of periodic wave](image1)

On the grid to the right, draw at least one full wave with the same amplitude and half the wavelength of the given wave. [2]

24. One end of a rope is attached to a variable speed drill and the other end is attached to a 5.0-kilogram mass. The rope is draped over a hook on a wall opposite the drill. When the drill rotates at a frequency of 20.0 Hz, standing waves of the same frequency are set up in the rope. The diagram below shows such a wave pattern.

![Diagram of wave pattern](image2)

a. What is the speed of the wave? [2]

b. Name one variable you could change to increase the speed of this wave. Explain your reasoning. [1]
## TEST SCORE BREAKDOWN BY STANDARD

**Student: Example A**

**Assessment: Unit 1 Mechanical Waves**

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Test Answer</th>
<th>Student Answer</th>
<th>Correct</th>
<th>Points Earned</th>
<th>Out Of</th>
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<td></td>
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<td>MW3 Sound Waves: I can describe the properties and behaviors of sound waves.</td>
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<tr>
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<tr>
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<td>MW3 Sound Waves: I can describe the properties and behaviors of sound waves.</td>
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<tr>
<td>10</td>
<td>MW3 Sound Waves: I can describe the properties and behaviors of sound waves.</td>
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<tr>
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<td>MW4 Interference: I can describe how two waves interact at a point.</td>
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<td>1</td>
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<td>No</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
MW1 Simple Harmonic Motion: I can determine the period and frequency of an oscillation.

12. A duck bobs up and down in a lake 12 times in 36 seconds. What is the frequency of the duck’s motion?

1. 0.33 Hz  
2. 12 Hz  
3. 3.0 Hz  
4. 4.36 Hz

This question requires students to identify the definition of frequency. They need to know that the frequency of any continual motion is found by the number of cycles produced for every second. In this case, the student would identify that 12 bobs are completed every 36 seconds and compute 12/36s to get 0.33Hz.

MW2 Wave Characteristics: I can describe the effect of a wave on a medium.

22. Which diagram best represents the motion of the particle at position C as the wave moves to the right?

1.  
2.  
3.  
4.  

2, 3, 6, 12, 14, 16, 18, 23
This question requires students to determine the properties of the wave based on the wave type. The student would need to identify that the wave shown in the image is a longitudinal wave, which would inform students that the particles of the wave will move parallel to the waves motion. Since this wave is moving to the right, the particles will move to the right and then back, making choice 4 the correct answer.

<table>
<thead>
<tr>
<th>MW3 Sound Waves: I can describe the properties and behaviors of sound waves.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4, 5, 7, 10, 13, 25c, 26, 27b</td>
</tr>
</tbody>
</table>

25. A dolphin uses specific sounds, called ‘clicks’ to communicate under water. A dolphin sends a 80 kHz click down through the ocean water. It bounces off the ocean floor 400 meters below the dolphin, bounces off a flat ocean bottom and returns to the dolphin as an echo 0.63 seconds after it was sent.

   c. How would increasing frequency change the sound produced? [1]

This standard requires students to build on their basic knowledge of waves from standards MW1 and MW2 to know specific information pertaining to sound waves. In this case, the student needs to identify what factor of the sound heard would change with an increase in frequency in the sound wave. As frequency determines the pitch of the sound, an increase in frequency would increase the pitch heard.

<table>
<thead>
<tr>
<th>MW4 Interference: I can describe how two waves interact at a point.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 8, 11, 15, 24a</td>
</tr>
</tbody>
</table>

1. Two wave sources operating in phase in the same medium produce the circular wave patterns shown in the diagram. The solid lines represent wave crests and the dashed lines represent wave troughs.

Which point is at a position of maximum destructive interference?

   1. A  3. C
   2. B  4. D

This question requires students to determine how two separate waves will interfere along their paths. Wave interference can either be destructive (wave amplitudes are in opposite directions when they meet) or constructive (wave amplitudes are in the same direction when they meet). To determine destructive interference, students would be looking for a point in the image when a solid line (crest) meets a dotted line (trough). This occurs at point B, choice 2.
Independent Student Reflection Document for Module #1: Mechanical Waves

The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Join with this CODE at Nearpod.com or in the app

**GTRLU**

Valid from Sat, Sep 21st 2019 until Mon, Oct 21st 2019

29 days remaining

Nearpod Reflection Document:

**WAVES REFLECTIONS**
Which standard was most difficult for you, based on your assessment score?

A. MW1  
B. MW2  
C. MW3  
D. MW4

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!

Ready? Enter your answer here.

If you plan to retake a second standard, which one will it be?

A. MW1  
B. MW2  
C. MW3  
D. MW4
What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard
B. Meet with Mrs. Carbone to discuss questions
C. Read topic and answer sample questions on Classroomphysic.com
D. Create flashcards to memorize terms and units that caused confusion
E. Watch videos on this topic at Khan Academy to deepen understanding
F. Go through notes
G. Other

What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?

Ready? Enter your answer here.
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of mechanical waves and the four standards associated with it in this unit, students will complete an in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to the creation and evaluation of their own musical instrument.

This particular project requires students to create their own instrument and analyze the properties of waves present within it. This project supports the goal by requiring students to apply properties of waves to a very specific scenario, their instrument of choice. Each instrument takes into account wave concepts such as amplitude, frequency, wavelength, velocity, resonance, standing waves, and constructive and destructive interference that were deeply discussed in this unit. Furthermore it requires students to look into other principles of sound beyond this unit that will be relevant; timbre, intensity, and beats for instance.

Completing this project requires students to address each of the four standards associated with waves. These standards will be addressed not only and how they create their own instrument and the sound that it makes but also in their written reflection addressing each of the concepts. The depth of learning is significantly increased when students can apply that learning directly to an application.

**Mechanical Waves Application Project:**

Now that you’ve explored and learned about mechanical waves, you and your partner(s) will now apply this knowledge to a topic of your interest by completing an application project of this unit. The deliverable for this project will consist of a 1-2 page typed report, with requirements outlined below. (Please choose 1 option!)

1. **Musical Instrument Research:** Choose a musical instrument that you are interested in (or even play!) and research the following items. Your 1-2 page paper must cite research / evidence for your claims:
   a. How does your instrument create sound wave (where is energy introduced)?
   b. How does the instrument produce different frequencies?
   c. What is timbre, and how does timbre make your instrument sound unique?
   d. How are different harmonics produced on your instrument and how do these make music?
   e. Other history / stories / facts that make this instrument interesting to you!

| MW1 | ____/5 |
| MW2 | ____/5 |
| MW3 | ____/5 |
| MW4 | ____/5 |
| TOT | ____/20 |
2. **Make your own music:** There are two options here, both of which only require a brief write-up (2 paragraphs) rather than a full report. In addition, you will present your music to Miss Carbone/Street and/or the class:
   a. Create/build your own musical instrument, using materials you provide or find in the room (and ask before you use!). This instrument should play actual music and notes (A, B, etc.) and will need to be demonstrated for full credit. It is even better if you record a video of this!!
   b. Use Audacity or another program to create or record your own song.

3. **Synthesize these ideas or suggest your own project idea**
   a. You must get approval from Ms. Carbone!
Re-take Assessment for Module #1: Mechanical Waves

Name: ____________________________  Unit 10 Waves Quest RETAKE

MW2: _______/11

1. The diagram below shows two pulses, A and B, moving to the right along a uniform rope.

Compared to pulse A, pulse B has
1) a slower speed and more energy
2) a faster speed and less energy
3) a faster speed and the same energy
4) the same speed and more energy

2. In the diagram below, X represents a particle in a spring.

Which diagram represents the motion of particle X as a longitudinal wave passes through the spring toward the right?
1) 2) 3) 4)

3. A wave is generated in a rope which is represented by the solid line in the diagram below. As the wave moves to the right, point P on the rope is moving toward which position?

1) A 2) B 3) C 4) D

4. An earthquake is traveling from the west to east through rock. If the particle are vibrating in a north-south direction, the wave must be classified as
1) transverse 2) longitudinal 3) a microwave 4) a radio wave

5. Base your answer to the following question on the diagram below which represents waves generated in a spring.

What type of wave is generated in the spring?
1) longitudinal 2) transverse 3) sound 4) light

6. Note that the following question has only three choices.
If the amplitude of a wave traveling in a rope is doubled, the speed of the wave in the rope will
1) decrease 2) increase 3) remain the same
Base your answers to questions 7 and 8 on the diagram of a Slinky spring shown below.

7. The interval representing one wavelength is
   1) AB  2) AC  3) AD  4) AE

8. The points that represent compressions are
   1) A and B  3) B and C
   2) A and C  4) B and D

9. A television remote control is used to direct pulses of electromagnetic radiation to a receiver on a television. This communication from the remote control to the television illustrates that electromagnetic radiation
   1) is a longitudinal wave
   2) possesses energy inversely proportional to its frequency
   3) diffracts and accelerates in air
   4) transfers energy without transferring mass

10. Which points on the wave diagram below are 90° out of phase with each other?

   1) A and E  2) B and C  3) C and D  4) D and E
11. The graph below shows displacement versus time for a particle of a uniform medium as a wave passes through the medium.

What is the frequency of the wave?
1) 10 Hz  2) 20 Hz  3) 50 Hz  4) 100 Hz

12. Base your answer to the following question on the diagram below, which represents a transverse wave.

How many cycles are shown in the diagram?
1) 1  2) 2  3) 3  4) 1.5

13. Which graph best represents the relationship between the frequency and period of a wave?
1)  

2)  

3)  

4)  

14. The diagram below shows a piston being moved back and forth to generate a wave. The piston produces a compression, C, every 0.50 second.

The frequency of this wave is
1) 1.0 Hz  2) 2.0 Hz  3) \(5.0 \times 10^{-1}\) Hz  4) \(3.3 \times 10^2\) Hz

15. Periodic waves are produced by a wave generator at the rate of one wave every 0.50 second. The period of the wave is
1) 1.0 s  2) 2.0 s  3) 0.25 s  4) 0.50 s

16. A physics student notices that 4.0 waves arrive at the beach every 20. seconds. The frequency of these waves is
1) 0.20 Hz  2) 5.0 Hz  3) 16 Hz  4) 80. Hz

17. The diagram below represents a periodic wave generated during a 1.5-second interval.

The frequency of the wave is
1) 1.0 Hz  2) 2.0 Hz  3) 0.50 Hz  4) 4.5 Hz

18. A periodic wave having a frequency of 5.0 hertz and a speed of 10. meters per second has a wavelength of
1) 0.50 m  2) 2.0 m  3) 5.0 m  4) 50. m

19. What is the velocity of a water wave that travels a distance of 10. meters in 5.0 seconds?
1) 5.0 m/s  2) 2.0 m/s  3) 15 m/s  4) 50. m/s
20. It takes 1 second for a sound wave to travel from a source to observer A. How long does it take the same sound wave to travel in the same medium to observer B, who is located twice as far from the source as observer A?
   1) 1/4 s  2) 2 s  3) 1/2 s  4) 4 s

21. Sound waves are described as
   1) mechanical and transverse
   2) mechanical and longitudinal
   3) electromagnetic and transverse
   4) electromagnetic and longitudinal

22. As a group of soldiers marches along a road, each soldier steps simultaneously. However, when crossing a bridge, the group does not step simultaneously in order to prevent the bridge from vibrating intensely. The phenomenon responsible for the intense vibrations is
   1) action and reaction
   2) conservation of momentum
   3) inertia
   4) resonance

23. The sound wave produced by a trumpet has a frequency of 440 hertz. What is the distance between successive compressions in this sound wave as it travels through air at STP?
   1) $1.5 \times 10^{-4}$ m  3) 1.3 m
   2) 0.75 m  4) $6.8 \times 10^{-5}$ m

24. Increasing the amplitude of a sound wave produces a sound with
   1) lower speed
   2) higher pitch
   3) shorter wavelength
   4) greater loudness

25. A singer demonstrated that she could shatter a crystal glass by singing a note with a wavelength of 0.320 meter in air at STP. What was the natural frequency of the glass?
   1) $9.67 \times 10^{-4}$ Hz  3) $1.03 \times 10^{3}$ Hz
   2) $1.05 \times 10^{2}$ Hz  4) $9.38 \times 10^{8}$ Hz

26. Which waves require a material medium for transmission?
   1) light waves  3) sound waves
   2) radio waves  4) microwaves

27. The frequency of a sound wave determines its
   1) amplitude  3) speed
   2) loudness  4) pitch

28. What is the wavelength of a 256-hertz sound wave in air at STP?
   1) $1.17 \times 10^{4}$ m  3) 0.773 m
   2) 1.29 m  4) $8.53 \times 10^{-7}$ m

29. Sound waves with a constant frequency of 250 hertz are traveling through air at STP. What is the wavelength of the sound waves?
   1) 0.76 m  3) 250 m
   2) 1.3 m  4) 83,000 m
30. The superposition of two waves traveling in the same medium produces a standing wave pattern if the two waves have
1) the same frequency, the same amplitude, and travel in the same direction
2) the same frequency, the same amplitude, and travel in opposite directions
3) the same frequency, different amplitudes, and travel in the same direction
4) the same frequency, different amplitudes, and travel in opposite directions

31. The diagram below shows two sources, A and B, vibrating in phase in the same uniform medium and producing circular wave fronts.

Which phenomenon occurs at point P?
1) destructive interference
2) constructive interference
3) reflection
4) refraction

32. The diagram below represents two pulses approaching each other from opposite directions in the same medium.

Which diagram best represents the medium after the pulses have passed through each other?
1) 
2) 
3) 
4) 

33. Two waves having the same frequency and amplitude are traveling in the same medium. Maximum constructive interference occurs at points where the phase difference between the two superposed waves is
1) 90°  2) 180°  3) 270°  4) 360°

34. The diagram below represents two waves traveling simultaneously in the same medium. At which of the given points will maximum constructive interference occur?

1) A  2) B  3) C  4) D
35. While playing, two children create a standing wave in a rope, as shown in the diagram below. A third child participates by jumping the rope.

What is the wavelength of this standing wave?
1) 2.15 m  
2) 4.30 m  
3) 6.45 m  
4) 8.60 m

36. The diagram below represents a standing wave.

The number of nodes and antinodes shown in the diagram is
1) 4 nodes and 5 antinodes
2) 5 nodes and 6 antinodes
3) 6 nodes and 5 antinodes
4) 6 nodes and 10 antinodes
Example of Gradebook Snapshot for Module #1: Mechanical Waves

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades are listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
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<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
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</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Mechanical Waves:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>MW1a</th>
<th>MW1b</th>
<th>MW2a</th>
<th>MW2b</th>
<th>MW3a</th>
<th>MW3b</th>
<th>MW4a</th>
<th>MW4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL POINTS</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>student A</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student B</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Student C</td>
<td>2.0</td>
<td>3.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>3.5</td>
<td>2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
## NYS Physics Standard:

**PI5.1:** Students can explain and predict different patterns of motion of objects (e.g., linear and uniform circular motion, velocity and acceleration, momentum and inertia).

- **5.1a** Measured quantities can be classified as either vector or scalar.
- **5.1b** A vector may be resolved into perpendicular components.*
- **5.1c** The resultant of two or more vectors, acting at any angle, is determined by vector addition.
- **5.1d** An object in linear motion may travel with a constant velocity* or with acceleration*. (Note: Testing of acceleration will be limited to cases in which acceleration is constant.)

## Supplies

- Unit 2 Test: 1D Kinematics (bubble sheet, test booklet, answer key, questions sorted by standard)
- Unit 2 Test Retake: 1D Kinematics (test booklet with questions sorted by standard, answer key)
- Sample student feedback score sheet
- Student re-assessment supplies and reflection guide
- List of standards paired with “I can” statements and standard codes
- Gradebook Sample
- Final Standards based unit project

## Summary:

This first unit is an excellent introduction for students to the meaning of motion. As a part of this unit, students will explore the concepts of distance, time, velocity, and constant acceleration. Lab activities such as the constant velocity buggy, maps of vector distances around the school, creating their own motion graphs with motion detectors, and the 40 yard acceleration dash will be used to help students to connect these new terms, equations, and units to information that they are already familiar with in their daily lives. After establishing a basic conceptual understanding of vectors displacement, velocity, and acceleration, students can then apply their learning to more in-depth activities, such as predicting where a marble that is rolled down a ramp and then launched off a table will land solely using kinematics equations and freefall. It will be stressed that we are looking only to describe motion on a single plane (1-dimension) and that this plane is independent of motion in other planes. The unit will conclude with a student-centered project in which students plan and create their own aerodynamic rocket and then launch these rockets straight into the sky and then at an angle with a goal of hitting a target. Kinematics equations and knowledge of motion in various directions will be necessary for accomplishing this task.
Students may be surprised how familiar they already are with the concepts of kinematics. Every time they participate in any sport, whether they be kicking a soccer ball or throwing a football, they're using their knowledge of kinematics. For example, students will learn in this unit that the angle for the maximum horizontal distance is 45°. A football quarterback already knows that that is his angle to achieve the maximum distance from his throw. Similarly, when students are driving, they will realize did they push the thrust to speed up and the brake to slow down. What will be shocking to them is the direction of the acceleration in comparison with their speed when they are slowing down. Is entire unit is an intro to Newtonian mechanics, which is relevant in life and specifically useful in occupations such as engineering when constructing something on a larger scale. Students already have more understanding of kinematics and they realize, and my goal is to draw on that understanding and pre knowledge as a launch point for this unit. At the end of the unit, by allowing students to add equations and concepts to their knowledge of kinematics, soon as love a deeper understanding and appreciation for the motion that is occurring all around them. This is especially applicable because this motion students can observe and do observe constantly.

The following standards are a list of what will be explored in this units and each represent a category that will be used in the standards based grading assessment cycle.

<table>
<thead>
<tr>
<th>Standards: 1D Kinematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard:</strong></td>
</tr>
<tr>
<td>K1</td>
</tr>
<tr>
<td>K2</td>
</tr>
<tr>
<td>K3</td>
</tr>
<tr>
<td>K4</td>
</tr>
</tbody>
</table>

Additional Notes: This unit has a strong focus on new math standards. These standards will be used in future units as well, but are broken down in this first unit to help students identify where they are weak in math knowledge required as a prerequisite for being successful in physics. These math concepts
are all sorted under one blanket standard “Math (MT)”. Each of these standards was reviewed during this first unit and will be cycled back to in future units.

### Standards: Math

<table>
<thead>
<tr>
<th>Standard: MT</th>
<th>Topic</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vectors &amp; Scalars</td>
<td>I can do the requisite math for physics.</td>
</tr>
<tr>
<td></td>
<td>Unit Conversions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vector Components</td>
<td></td>
</tr>
</tbody>
</table>

### Possible Misconceptions:

Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from New York Science Teacher: Physics Misconceptions, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.

### Standards: Kinematics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The location of an object can be described by stating its distance from a given point (ignoring direction).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The terms distance and displacement are synonymous and may be used interchangeably. Thus the distance an object travels and its displacement are always the same.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Velocity is another word for speed. An object’s speed and velocity are always the same.</td>
<td></td>
</tr>
</tbody>
</table>
| K2 | Motion Graphs | - Distance vs. time graphs are synonymous with velocity vs. time graphs  
- Slope trend is confused with values of the data points  
- Time is defined in terms of its measurement.  
- Acceleration is confused with speed.  
-  |
| --- | --- | --- |
| K3 | Freefall | - If an object has a speed of zero, even instantaneously, it has no acceleration.  
- Acceleration is confused with speed.  
- Acceleration due to gravity is dependent on the mass of an object  
- Acceleration due to gravity is dependent on the velocity of an object  
- Speed in a direction must mean there is also an acceleration  
- |
| K4 | Angled Projectiles | - Velocity at an angle can be used to solve for components  
- Acceleration always occurs in the same direction as an object is moving.  
- If an object has a speed of zero, even instantaneously, it has no acceleration.  
- Acceleration is confused with speed.  
- Acceleration due to gravity is dependent on the mass of an object  
- Motion on a single plane is dependent on motion in other planes.  
- |
Appendix of Supplemental Materials for Module Kit #2

Test for Module #2: Kinematics

Name: ________________________________  Unit 2: Kinematics

Exam: Kinematics

Directions:

- Mark multiple choice questions on the separate answer sheet. Only answers marked on the answer sheet will be scored. Use pen (preferred) or pencil. Do not select answers for constructed response questions in the boxed portions of the answer sheet.
- Write your responses in pen to constructed-response questions in this packet. Use complete sentences and proper grammar when appropriate.
- Show ALL work for calculations in FSA (formula, solution (WITH UNITS!!), answer (WITH UNITS!!) format.
- You may use the References Tables for Physical Setting / Physics as well as a pen/pencil, ruler, protractor, and scientific or graphing calculator on this exam.
1.) Figure 1: The graph represents the linear motion of a car. Use the information in Figure 1 for questions 1a and 1b.

![Graph of displacement vs. time for a car's motion](image)

a) The velocity of the car during interval CD is: [1]
   a. 0 m/s
   b. 5 m/s
   c. 15 m/s
   d. 20 m/s

b) The distance traveled by the car from 0 – 7 seconds is: [1]
   a. 0 m
   b. 5 m
   c. 20 m
   d. 40 m

2.) The graph below shows the relationship between the speed and elapsed time for an object falling freely from rest near the surface of a planet.

![Graph of speed vs. time for an object falling freely](image)

a) What is the total distance the object falls during the first 3.0 seconds? [1]

b) What is the acceleration due to gravity on this planet? [1]
3.) The speed of a wagon increases from 2.50 meters per second to 9.00 meters per second in 3.00 seconds as it accelerates uniformly down a hill. What is the magnitude of the acceleration during this 3.00-second interval? [1]

   a) 0.83 m/s²  
   b) 2.2 m/s²  
   c) 3.0 m/s²  
   d) 3.8 m/s²

4.) A ball thrown vertically upward reaches a maximum height of 30.0 meters above the surface of Earth. At its peak, the vertical velocity of the ball is [1]

   a) 0.0 m/s  
   b) 3.1 m/s  
   c) 9.8 m/s  
   d) 24 m/s

5.) A student throws a baseball vertically upward and then catches it. If vertically upward is considered to be the positive direction, which graph best represents, the relationship between velocity and time for the baseball? [Neglect friction.] [1]

6.) An astronaut drops a hammer from 2.00 meters above the surface of the Moon. If the acceleration due to gravity on the moon is 1.62 meters per second², how long will it take for the hammer to fall to the Moons’ surface? [1]

   a) 0.62 s  
   b) 1.2 s  
   c) 1.6 s  
   d) 2.5 s

7.) The graph represents the motion of a body moving along a straight line. According to the graph, which quantity related to the motion of the body is constant? [1]

   a. speed  
   b. velocity  
   c. acceleration  
   d. Displacement
8.) Which pair of graphs represents the same motion of an object? [1]

a.  

b.  

c.  

d.  

9.) A golf ball is propelled with an initial velocity of 60.0 meters per second at 37° above the horizontal. The horizontal component of the golf ball’s initial velocity is [1]

a) 30. m/s  b) 36 m/s  c) 40 m/s  d) 48 m/s

10.) An object is thrown horizontally off a cliff with an initial velocity of 5.00 meters per second. The object strikes the ground 3.00 seconds later. How far from the base of the cliff will the object strike the ground? [Neglect friction.] [1]

a) 2.9 m  b) 9.8 m  c) 15 m  d) 44 m

11.) If a car accelerates uniformly from rest to 15 meters per second over a distance of 100 meters, the magnitude of the car’s acceleration is [1]

a) 0.15 m/s²  b) 1.1 m/s²  c) 2.3 m/s²  d) 6.7 m/s²
12.) A hiker starts at point $P$ and walks 2.0 kilometers due east and then 1.4 kilometers due north. The vectors in the diagram below represent these two displacements.

![Diagram](image)

a. On the diagram above, use a ruler to construct the vector representing the hiker’s resultant displacement. [1]

b. Determine the magnitude of the hiker’s resultant displacement. [1]

c. Using a protractor, determine the angle between east and the hiker’s resultant displacement. [1]

In *The Return of the Jedi*, Luke Skywalker battled a Rancor in Jabba the Hutt’s palace. He defeated the Rancor by throwing a rock at a button that dropped a gate upon the Rancor while it was walking under it.

13.) If the button was horizontally 8.00 meters away from Luke and the Rancor was 1.80 seconds away from being directly under the gate. What horizontal velocity would Luke have to throw the rock at the button to drop the gate directly upon the Rancor? [2]
14.) An object is kicked off of a 130 meter high cliff with an initial horizontal velocity of 12 meters per second.

   a) Calculate the time for the projectile to reach the ground. (Ignore Air Resistance) [2]

   b) Calculate the horizontal distance traveled by the projectile. (Ignore Air Resistance) [2]

   c) How would air resistance affect the horizontal displacement of the object? [1]

The driver of a car traveling 26.8 m/s sees a deer on the highway 30.0 meters ahead and slams on the brakes. The car’s brakes decelerate the car at a rate of 10.0 m/s² causing the car to eventually come to a stop.

15.) How far does the car travel while braking? Does the car hit the deer? [2]
16. A projectile is fired from the ground with an initial velocity of 160 meters per second at an angle of 40° above the horizontal level ground.

a) Sketch the horizontal and vertical components of velocity at points A, B, & Peak. [2]

b) What is the magnitude and direction of the projectile’s acceleration at the peak? [1]

c) Calculate the time for the projectile to reach its peak: [2]

d) Calculate the maximum horizontal distance traveled by the projectile. [2]
## TEST SCORE BREAKDOWN BY STANDARD

Student: Example A  
Assessment: Unit 2 Kinematics

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Test Answer</th>
<th>Student Answer</th>
<th>Correct</th>
<th>Points Earned</th>
<th>Out Of</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td>b</td>
<td>b</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td>b</td>
<td>b</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12a</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12b</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12c</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1a</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>c</td>
<td>c</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>d</td>
<td>c</td>
<td>No</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2a</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2b</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>d</td>
<td>d</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>e</td>
<td>e</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>d</td>
<td>d</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td>a</td>
<td>a</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td>c</td>
<td>c</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td>c</td>
<td>c</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14a</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>14b</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14c</td>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td>d</td>
<td>a</td>
<td>No</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>16a</td>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>16b</td>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16c</td>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>16d</td>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>#</td>
<td>Standards</td>
<td>Test Answer *</td>
<td>Student Answer</td>
<td>Correct Points Earned</td>
<td>Out Of</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>-----------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Your Score</td>
<td>Percent Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 out of 32</td>
<td>75 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Proficiency Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* A Test Answer of &quot;X&quot; indicates that any answer was acceptable; EC indicates the question was for Extra Credit.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard</th>
<th>Points</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1 Velocity &amp; Acceleration: I can analyze the motion of objects undergoing constant acceleration or uniform motion.</td>
<td>9 / 9</td>
<td>100 %</td>
</tr>
<tr>
<td>K2 Motion Graphs: I can use slopes and areas to determine kinematic values.</td>
<td>4 / 7</td>
<td>57.14 %</td>
</tr>
<tr>
<td>K3 Freefall: I can determine the motion of an object solely under the influence of gravity.</td>
<td>7 / 8</td>
<td>87.5 %</td>
</tr>
<tr>
<td>K5 Angled Projectiles: I can analyze the motion of an object launched at an angle.</td>
<td>4 / 8</td>
<td>50 %</td>
</tr>
</tbody>
</table>

**Standard** | **Questions linked to Standard**
---|---
K1: | 3, 11, 12a, 12b, 12c, 13, 15
K2: | 1a, 1b, 2a, 2b, 5, 7, 8
K3: | 4, 6, 10, 14a, 14b, 14c
K4: | 9, 16a, 16b, 16c, 16d
The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback to me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Nearpod Reflection Document:

**KINEMATICS REFLECTIONS**
Which standard was most difficult for you, based on your assessment score?

- A. K1
- B. K2
- C. K3
- D. K4
- E. MATH

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!

Ready? Enter your answer here.

If you plan to retake a second standard, which one will it be?

- A. K1
- B. K2
- C. K3
- D. K4
- E. MATH
What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard
B. Meet with Mrs. Carbone to discuss questions
C. Read topic and answer sample questions on ClassroomPhysics.com
D. Create flashcards to memorize terms and units that caused confusion
E. Watch videos on this topic at Khan Academy to deepen understanding
F. Go through notes
G. Other

What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?

Ready? Enter your answer here.
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However, research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of the standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to the creation and prediction of both a rocket launch and a marble run.

This particular project requires students to combine their knowledge of both freefall motion with projectile motion, along with combining aspects of forces and aerodynamics, to create their final project. Students will need to create a rocket that will experience the lowest magnitude of air resistance possible. They can get creative with supplies and utilize various sources to create the hands-on model. After the model has been created, students will need to launch the rocket to find its initial velocity using kinematics equations related to freefall and motion in one dimension. They will have various calculations to complete with this value prior to completing their final challenge, an angled projectile launch. This final challenge ensures that the students understand and can apply all four of the kinematics standards. They will need to predict the launch distance of their rocket launched at an angle on the soccer field. Based on the accuracy of their calculations, they will be able to see their percent error by finding the distance the rocket landed from the goal.

Completing this project requires students to address each of the four standards associated with kinematics. These standards will be addressed not only and how they create their rocket but also in their written reflection and calculations addressing each of the concepts. Students will have a good idea of how effective these formulas are for predicting motion when they see how close their rockets get to the target goal. The depth of learning is significantly increased when students can apply that learning directly to an application.

### Kinematics Application Project: Rocket Lab

**Goal / Objective:** To construct an aerodynamic rocket with the maximum range and velocity and determine the values to accurately launch at a target.
**Challenge 1:**
You and your group need to construct a rocket out of a 2-Liter soda bottle with the goal of maximizing range and initial velocity. Use the internet, book, class resources, etc. to develop a model of your rocket (fins, nose cone, etc.) and determine the shape and materials to make these out of.
Draw your model on the graph drawing paper provided, labeling materials and reasons.
Staple this to your project.

**Challenge 2:** Determine the initial speed of your rocket

Considering equations for free fall, determine the speed of your rocket below by launching it straight into the air. You may want to consider such factors as time and air resistance. Use the space below to show ALL calculations, equations, and data in a table.

When your rocket is ready to be fired, watch carefully and start your timer as soon as the rocket blasts off straight up. Stop the timer when it returns back to the ground. Repeat this procedure for one more trial and record ALL times in the table below. All group members should time.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Timer 1</th>
<th>Timer 2</th>
<th>Timer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The initial velocity of your group’s rocket is ______________________.
Challenge 3: Hit a target when launched at an angle.

You will be launching the rocket at an angle with the goal of landing the rocket in the soccer goal. Place an object under the rocket so that it sits at an angle and measure this angle with a protractor:

Angle: __________

Using your initial velocity from above and the angle you measured, determine the distance that the rocket will travel. Show your calculations and final answer here:

From the soccer goal, measure the distance that you calculated and place your rocket at this distance pointing at the goal. When ready, fire your rocket and calculate the error distance by measuring the difference from your landing point to the goal.

Error Distance: _____

What is your percent error?

Explain what factors may have accounted for this error.
Re-take Assessment for Module #2: Kinematics

Name: ____________________________

Unit 2: Kinematics

Unit 2 Kinematics Test RETAKE

K1

1.) The driver of a car traveling 20.0 m/s sees a deer on the highway 28.0 meters ahead and slams on the brakes. The car’s brakes decelerate the car at a rate of 6.0 m/s\(^2\) causing the car to eventually come to a stop.

   a.) How long does it take the car to stop? [2]

   b.) How far does the car travel while braking? [2]

2.) A car with an initial velocity of 16.0 meters per second west slows uniformly to 6.0 meters per second west in 4.0 seconds. What is the acceleration of the car during this 4.0-second interval? [1]

   1. 2.5 m/s\(^2\) west
   2. 2.5 m/s\(^2\) east
   3. 4.0 m/s\(^2\) west
   4. 4.0 m/s\(^2\) east

3.) In an intense game of nerf, Mr. Baker wants to hit Mr. Eggleston with his nerf dart. Mr. Eggleston is 1.2 seconds from being 5.0 meters directly in front of Mr. Baker. What horizontal velocity would Mr. Baker have to shoot the nerf bullet at to hit Mr. Eggleston at that point? [2]

4.) In a drill during basketball practice, a player runs the length of the 30-meter court and back. The player does this three times in 60. seconds. The average speed of the player during the drill is [1]

   1. 0.0 m/s
   2. 0.50 m/s
   3. 3.0 m/s
   4. 30. m/s
5. A car initially traveling at a speed of 16 meters per second accelerates uniformly to a speed of 20 meters per second over a distance of 36 meters. What is the magnitude of the car’s acceleration? [1]
   1. 0.11 m/s²  b) 2.0 m/s²  c) 0.22 m/s²  d) 9.0 m/s²

K2

6. Which pair of graphs represents the same motion? [1]

   1.  
   2.  
   3.  
   4.  

7. The graph below shows the velocity of a race car moving along a straight line as a function of time.
   a. What is the magnitude of the displacement of the car from t = 2.0 seconds to t = 4.0 seconds? [1]

   b. What is the magnitude of the acceleration of the car from t = 2.0 seconds to t = 4.0 seconds? [1]
5.) The velocity-time graph represents the motion of a 3-kilogram cart along a straight line. The cart starts at $t = 0$ and initially moves north.

   a. What is the magnitude of the acceleration of cart at $t = 4$ seconds? [1]

   b. What is the displacement of the cart from 3 to 7 seconds? [1]

   c. What is the velocity of the cart at 0 seconds? [1]

6.) The graph below shows the relationship between speed and elapsed time for a car moving in a straight line.

   a. What is the total distance the car travel during the first 8.0 seconds? [1]

   b. What is the acceleration of the car? [1]

K3

7.) Terrance launches a rocket upward, starting with an initial velocity of 24 m/s. What is the velocity of the rocket after 3.43 seconds? [1]
8.) A 5.0-kilogram sphere, starting from rest, falls freely 22 meters in 3.0 seconds near the surface of a planet. Compared to the acceleration due to gravity near Earth’s surface, the acceleration due to gravity near the surface of the planet is approximately [1]

1. the same
2. twice as great
3. one-half as great
4. four times as great

9.) A ball is thrown vertically upward with an initial velocity of 29.4 meters per second. What is the maximum height reached by the ball? [Neglect friction.] [1]

1. 14.7 m
2. 29.4 m
3. 44.1 m
4. 88.1 m

10.) An object is kicked off of a 112 meter high cliff with an initial horizontal velocity of 13.5 meters per second.

a) Calculate the time for the projectile to reach the ground. [Ignore Air Resistance] [2]

b) Calculate the maximum horizontal distance covered by the projectile. [Ignore Air Resistance] [2]

11.) An object was projected horizontally from a tall cliff. The diagram represents the path of the object, neglecting friction.

At which point is the object most likely to land, assuming that it was subject to air resistance? [1]

1. P
2. Q
3. R
4. S
12.) A ball is thrown horizontally at a speed of 24 meters per second from the top of a cliff. If the ball hits the ground 4.0 seconds later, approximately how high is the cliff? [1]

1. 6.0 m
2. 39 m
3. 78 m
4. 96 m

K4

13.) A baseball is hit with an initial velocity of 15 meters per second at an angle of 35 degrees above the horizontal. What is the horizontal component of the baseball’s initial velocity? [1]

1. 8.6 m/s
2. 9.8 m/s
3. 12 m/s
4. 15 m/s

14.) A projectile is fired from the ground with an initial velocity of 120 meters per second at an angle of 30° above the horizontal level ground.

a. Sketch the horizontal and vertical components of velocity at points A, B, & Peak. [2]
b. What is the magnitude and direction of the projectile’s acceleration at the peak? [1]

c. Calculate the vertical height of the projectile at its peak. [2]

d. Calculate the maximum horizontal distance traveled by the projectile. [2]
Example of Gradebook Snapshot for Module #2: Kinematics

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades are listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
<thead>
<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Kinematics:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>K1a</th>
<th>K1b</th>
<th>K2a</th>
<th>K2b</th>
<th>K3a</th>
<th>K3b</th>
<th>K4a</th>
<th>K4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL POINTS</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Student A</td>
<td>2.0</td>
<td>3.0</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
<td>3.5</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Student B</td>
<td>3.5</td>
<td>4.0</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student C</td>
<td>4.0</td>
<td>4.0</td>
<td>2.0</td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>
**Module Kit #3: Electromagnetic Waves**

<table>
<thead>
<tr>
<th>Title:</th>
<th>Unit 3: Electromagnetic Waves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source/website:</td>
<td>Created by E. Carbone 10/1/19</td>
</tr>
<tr>
<td><strong>NYS Physics Standard:</strong></td>
<td><strong>Key Ideas:</strong></td>
</tr>
<tr>
<td></td>
<td>PS4.B: Electromagnetic Radiation: Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.</td>
</tr>
<tr>
<td></td>
<td>PS4.B Electromagnetic Radiation: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.</td>
</tr>
<tr>
<td></td>
<td>PS4.A Wave Properties: The location and size of an image are related to the location and size of an object for a plane mirror. The location and size of an image (real or virtual) are related to the location and size of an object and the focal distance for convex and concave mirrors.</td>
</tr>
<tr>
<td></td>
<td>PS4.A Wave Properties: Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.</td>
</tr>
<tr>
<td></td>
<td>PS4.C: Information Technologies and Instrumentation: Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, and scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.</td>
</tr>
</tbody>
</table>

**Supplies**

- Electromagnetic Waves Standards one-pager
- List of standards paired with “I can” statements and standard codes
- Unit Test: Electromagnetic Waves (bubble sheet, test booklet, answer key, questions sorted by standard)
- Electromagnet Waves Test Retake: 1 D Kinematics (test booklet with questions sorted by standard, answer key)
- Sample student feedback score sheet
- Student re-assessment reflection guide

**Summary:**

This first unit is an excellent introduction for students to another of the more conceptual topics in high school physics. As a part of this unit, students will explore the properties and
various types of electromagnetic waves. Students will look into what some of these waves are used for, how they move through various medium, the factors that affect these waves. Students will also explore unique properties of light when it interacts with boundaries. In this unit, the founders will both be flat and curved surfaces always demonstrating a change in medium from what the wave was into what it's entering. This will allow students to look at reflection and refraction of waves. Additionally students will study properties of waves as they move around boundaries as in the case of diffraction or the apparent change in frequency of the wave due to motion as in the Doppler effect. Students will end this unit by exploring geometrical optics using mirrors and lenses that are curved. Finally, all three of these standards will be wrapped up together in an application standard we’re students will see how these qualities of light apply to many current fields in science. This unit has the unique capability July students to explore as a 4th standard actual applications of optics. Students can explore cameras come in the eye, spectrometers, weather patterns, microscopes, telescopes, lasers, and a vast array of other current applications. Most of these applications will just be studied to give students a piece of information into the depth of the topic. There are many career options in optics and waves for students that I would love for them to explore further as many of them probably did not even realize that they huge field existed.

Throughout this unit, students will perform a Doppler effect lab, a refraction lab shining light through oil, experiments with spherical mirrors and spherical lenses, it will build their own telescope, they’ll perform diffraction using one of their own hairs to calculate the width of it, and various other experiments that allows students to investigate. Students will conclude this unit with a project that draws all standards together, but most predominantly address is standard for, the standard concerning application of optics. As part of this standard as well, students will take a field trip to University of Rochester optics as well as a local optics company.

The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standard:</th>
<th>Topic:</th>
<th>Knowledge Check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP1</td>
<td>EM Spectrum</td>
<td>I can describe the characteristics of different electromagnetic waves.</td>
</tr>
</tbody>
</table>
### Standards: Electromagnetic Waves

<table>
<thead>
<tr>
<th>Standard:</th>
<th>Topic:</th>
<th>Possible Common Misconceptions:</th>
</tr>
</thead>
</table>
| OP1       | EM Spectrum | - Light always passes straight through a transparent material without changing direction.  
- All light is visible  
- The velocity of visible light is different from other light forms on the EM spectrum  
- All EM waves have the same energy  
- Radio Waves are a type of sound wave  
- All types of radiation is harmful  
- A white light source, such as an incandescent or fluorescent bulb, produces light made up of only one color.  
- Sunlight is different from other sources of light because it contains no color.  
- A colored light striking an object produces a shadow behind it that is the same color as the light. For example, when red light strikes an object, a red shadow is formed.  
- When white light passes through a colored filter, the filter adds color to the light. |

Possible Misconceptions: Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery of electromagnetic waves that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from New York Science Teacher: Physics Misconceptions, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.
White light is colorless and clear, enabling you to see the “true” color of an object.

Wave Phenomenon

- When white light passes through a prism, color is added to the light.
- Light reflects from a shiny surface in an arbitrary manner.
- Light is reflected from smooth mirror surfaces but not from non-shiny surfaces.
- Light shines on a translucent material and illuminates it so it can be seen. Light does not travel from the translucent material to the eye.
- Light always passes straight through a transparent material without changing direction.
- When an object is viewed through a transparent solid or liquid material the object is seen exactly where it is located.
- The purpose of the screen is to capture the image so that it can be seen. The screen is necessary for the image to be formed. Without a screen there is no image.

Geometrical Optics

- A mirror reverses everything.
- For an observer to see the mirror image of an object, either the object must be directly in front of the mirror, or if not directly in front, then the object must be along the observer’s line of sight to the mirror. The position of the observer is not important in determining whether the mirror image can be seen.
- An observer can see more of his image by moving further back from the mirror.
- Curved mirrors make everything distorted.
- Students will often think about how a lens forms an image of a self-luminous object in the following way. They envision that a “potential image” which carries information about the object leaves the self-luminous object and travels through the space to the lens. When passing through the lens, the “potential image” is turned upside down and may be changed in size.
- When sketching a diagram to show how a lens forms an image of an object, only those light rays are drawn which leave the object in straight parallel lines.
- Blocking part of the lens surface would block the corresponding part of the image.
- An image can be seen on the screen regardless of where the screen is placed relative to the lens. To see a larger image on the screen, the screen should be moved further back.
- An image is always formed at the focal point of the lens.
<table>
<thead>
<tr>
<th>OP4</th>
<th>Applications of Optics</th>
</tr>
</thead>
</table>
| - The size of the image depends on the diameter of the lens.  
- The mirror image of an object is located on the surface of the mirror. The image is often thought of as a picture on a flat surface.  
- The way a mirror works is as follows: The image first goes from the object to the mirror surface. Then the observer either sees the image on the mirror surface of the image reflects off the mirror and goes into the observer’s eye. |
| - Polaroid sunglasses are just dark glass or dark plastic.  
- The pupil of the eye is a black object or spot on the surface of the eye.  
- The eye receives upright images.  
- The lens is the only part of the eye responsible for focusing light.  
- The lens forms and image (picture) on the retina. The brain then “looks” at this image and that is how we see.  
- The eye is the only organ for sight; the brain is only for thinking.  
- The rules for mixing color paints and crayons are the same as the rules for mixing colored lights.  
- The primary colors for mixing colored lights are red, blue and yellow.  
- The shades of gray in a black and white newspaper picture are produced by using inks with different shades of gray.  
- The different colors appearing in colored pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.  
- The mixing of colored paints and pigments follow the same rules as the mixing of colored lights.  
- The primary colors used by artists (red, yellow and blue) are the same as the primary colors for all color mixing.  
- Color is a property of an object, and is independent of both the illuminating light and the receiver (eye).  
- Explanations of visual phenomena involving color perception usually involve only the properties of the object being observed, and do not include the properties of the eye-brain system. |
Appendix of Supplemental Materials for Module Kit #3
Test for Module #3: Electromagnetic Waves

1. The diagram below represents a light ray reflecting from a plane mirror. The angle of reflection for the light ray is

![Diagram of light ray reflecting from plane mirror]

1. 25°
2. 35°
3. 50°
4. 65°

2. A light ray traveling in air enters a second medium and its speed slows to $1.71 \times 10^8$ meters per second. What is the absolute index of refraction of the second medium?

1. 1.00
2. 0.570
3. 1.75
4. 1.94

3. What is the speed of light ($f = 5.09 \times 10^{14}$ Hz) in ethyl alcohol?

1. $4.53 \times 10^3$ m/s
2. $2.43 \times 10^2$ m/s
3. $1.24 \times 10^8$ m/s
4. $2.21 \times 10^8$ m/s

4. If monochromatic light passes from water into air with an angle incidence of 35°, which characteristic of the light will remain the same?

1. frequency
2. wavelength
3. speed
4. direction

5. A gamma ray photon and a microwave photon are traveling in a vacuum. Compared to the wavelength and energy of the gamma ray photon, the microwave photon has a

1. shorter wavelength and less energy
2. shorter wavelength and more energy
3. longer wavelength and less energy
4. longer wavelength and more energy

6. A $5.09 \times 10^{14}$-hertz electromagnetic wave is traveling through a transparent medium. The main factor that determines the speed of this wave is the

1. nature of the medium
2. amplitude of the wave
3. phase of the wave
4. distance traveled through the medium

7. Compared to visible light, ultraviolet radiation is more harmful to human skin and eyes because ultraviolet radiation has a

1. higher frequency
2. longer period
3. higher speed
4. longer wavelength

8. Compared to the period of a microwave, the period of an infrared ray is

1. less
2. greater
3. the same
9. Which characteristics of a light wave remain constant when the light wave travels from air into corn oil?
   1. speed and frequency
   2. wavelength and frequency
   3. period and frequency
   4. wavelength and period

10. A beam of monochromatic light (\(f=5.09 \times 10^{14}\) Hz) has a wavelength of 589 nm in air. What is the wavelength of this light in Lucite?
   1. 150 nm
   2. 393 nm
   3. 589 nm
   4. 884 nm

11. The diagram below represents a view from above of a tank of water in which parallel wave fronts are traveling toward a barrier. Which arrow represents the direction of travel for the wave fronts after being reflected from the barrier?

12. Which color of light has a wavelength of 5.0 \(\times\) 10\(^{-7}\) meter in air?
   1. blue
   2. green
   3. orange
   4. Violet

13. The diagram below shows light rays in air about to strike a glass window. When the rays reach the boundary between the air and the glass, the light is

14. Parallel wave fronts incident on an opening in a barrier are diffracted. For which combination of wavelength and size of opening will diffraction effects be greatest?
   1. short wavelength and narrow opening
   2. short wavelength and wide opening
   3. long wavelength and narrow opening
   4. long wavelength and wide opening

15. A beam of monochromatic light travels through flint glass, crown glass, Lucite, and water. The speed of the light beam is slowest in
   1. flint glass
   2. crown glass
   3. Lucite
   4. water
16. How much time does it take light from a flashlight to reach a subject 6.0 meters across a room?
   1. $5.0 \times 10^{-9}$ s
   2. $2.0 \times 10^{-8}$ s
   3. $5.0 \times 10^{-8}$ s
   4. $2.0 \times 10^{-7}$ s

17. An electromagnetic wave is produced by charged particles vibrating at a rate of $3.9 \times 10^{8}$ vibrations per second. The electromagnetic wave is classified as
   1. a radio wave
   2. an infrared wave
   3. an x-ray
   4. visible light

18. Sunlight is composed of various intensities of all frequencies of visible light. The graph represents the relationship between light intensity and frequency. Based on the graph, which color of visible light has the lowest intensity?

19. When a ray of light traveling in water reaches a boundary with air, part of the light ray is reflected and part is refracted. Which ray diagram best represents the paths of the reflected and refracted light rays?
20. When observed from Earth, the wavelengths of light emitted by a star are shifted toward the red end of the electromagnetic spectrum. This redshift occurs because the star is:

1. at rest relative to Earth
2. moving away from Earth
3. moving toward Earth at decreasing speed
4. moving toward Earth at increasing speed

21. The diagram below represents two pulses approaching each other from opposite directions in the same medium.

Which diagram best represents the medium after the pulses have passed through each other?

22. The diagram below represents a standing wave in a string. Use this diagram for questions 21 and 22.

22. Maximum constructive interference occurs at the

1. antinodes A, C, and E
2. nodes A, C, and E
3. antinodes B and D
4. nodes B and D

23. The wavelength of a standing wave is indicated between points:

1. A and C
2. C and E
3. A and E
4. D and D

24. If you are standing in front of a plane mirror, the properties of your image will be:

1. Real and upright
2. Real and inverted
3. Virtual and upright
4. Virtual and inverted

25. A concave mirror with a focal length of 20 centimeters is used to examine a 0.50-centimeter-wide freckle on a person's face. The person's face is located 10 centimeters from the mirror. The image of the freckle produced by the mirror is

1. real and inverted
2. real and upright
3. virtual and inverted
4. virtual and upright
26. A pencil with a height of 8.0 cm is placed 10.0 cm in front of a converging mirror and its image appears a distance of 20.0 cm behind the mirror. The image’s properties are:

1. Virtual, upright and larger than the object
2. Real, inverted and larger than the object
3. Virtual, inverted and smaller than the object
4. Real, upright, and smaller than the object.

27. For any convex mirror, with parallel rays of light hitting the surface and reflecting, how would you describe the image created?

1. Real because it cannot be projected on a screen
2. Virtual because it cannot be projected on a screen
3. Real because it can be projected on a screen
4. Virtual because it can be projected on a screen

28. A ray of monochromatic light of frequency $f = 5.09 \times 10^{14}$ hertz is traveling from water into medium X. The angle of incidence in water is 45° and the angle of refraction in medium X is 29°, as shown.

a) Calculate the absolute index of refraction of medium X. [2]

b) Medium X is most likely what material? [1]

c) Use a ruler and protractor to draw in the reflected ray that occurs at the boundary of water and medium X. Be sure to label the reflected angle. [1]

d) If the wavelength of the light beam in the water is $5.8 \times 10^{-6}$ m, what is its new wavelength in medium X? [2]

29. Calculate the wavelength in a vacuum of a radio wave having a frequency of $2.2 \times 10^6$ hertz. [Show all work, including the equation and substitution with units.] [2]
30. A $1.50 \times 10^6$ meter-long segment of an electromagnetic wave having a frequency of $6.00 \times 10^{12}$ hertz is represented below. Which type of electromagnetic wave does the segment in the diagram represent? [1]

31. In the diagram to the right, the 1 cm tall object is placed 3 cm away from a converging lens with a focal length of 2 cm. Using either a ray diagram, mathematics, or your own knowledge, determine:

a. The location of the image. [1]

b. The height of the image. [1]

c. Whether the image is real or virtual. [1]

d. Whether the lens is concave or convex. [1]

32. An object is placed 0.40 meter in front of a convex (converging) lens whose focal length is 0.30 meter. What is the image distance? [2]

33. Use ray optics to determine the location of the image in the diagrams below for an object located at point A.
## TEST SCORE BREAKDOWN BY STANDARD

**Student: Example A**

**Assessment: Unit 3 Electromagnetic Waves**

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Correct Answer</th>
<th>Student Answer</th>
<th>Points Earned</th>
<th>Out Of</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>MW4 Interference: I can describe how two waves interact at a point.</td>
<td>2</td>
<td>2</td>
<td>Yes</td>
<td>1 1</td>
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<td>5</td>
<td>OP1 EM Spectrum: I can describe the characteristics of different electromagnetic waves.</td>
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<td>7</td>
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<td>2</td>
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<td>3</td>
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<td>11</td>
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<td>4</td>
<td>No</td>
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<td>13</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
<td>4</td>
<td>4</td>
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<td>14</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<td>3</td>
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<td>15</td>
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<td>Yes</td>
<td>1 1</td>
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<td>16</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<td>2</td>
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<td>1 1</td>
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<tr>
<td>19</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<td>4</td>
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<td>1 1</td>
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<td>28a</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
<td></td>
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<td>28b</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<td>28c</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<td>#</td>
<td>Standards</td>
<td>Correct Answer</td>
<td>Student Answer</td>
<td>Points Earned</td>
<td>Out Of</td>
</tr>
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<tr>
<td>28d</td>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
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<tr>
<td>24</td>
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<td>1</td>
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<tr>
<td>25</td>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
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<td>1</td>
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<td>26</td>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
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<td>27</td>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
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<td>No</td>
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<td>31a</td>
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<td>31b</td>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
<td>0</td>
<td>1</td>
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<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
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<td>31d</td>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
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<td>32</td>
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<td>33</td>
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<td>2</td>
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</tbody>
</table>

Your Score: 35 out of 44
Percent Score: 79.55%

Proficiency Level

* A Correct Answer of "X" indicates that any answer was acceptable. EC indicates the question was for Extra Credit.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Points</th>
<th>Percent</th>
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<tbody>
<tr>
<td>MW4 Interference: I can describe how two waves interact at a point.</td>
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<td>66.67%</td>
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<tr>
<td>OP1 EM Spectrum: I can describe the characteristics of different electromagnetic waves.</td>
<td>8 / 9</td>
<td>88.89%</td>
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<tr>
<td>OP2 Waves Phenomenon: I can describe phenomena that are characteristic of waves.</td>
<td>18 / 20</td>
<td>90%</td>
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<tr>
<td>OP3 Geometrical Optics: I can determine properties of an image in a lens or mirror system.</td>
<td>7 / 12</td>
<td>58.33%</td>
</tr>
</tbody>
</table>

**Standard**

**OP1:**
I can describe the characteristics of different electromagnetic waves.

**Questions linked to Standard**

5, 7, 8, 12, 17, 18, 29, 30
This standard addresses students’ knowledge of electromagnetic waves. These waves are the same type of wave and are only varied by their frequency and wavelengths. The higher the frequency of the electromagnetic wave, the higher the energy as they are directly correlated. However, wave speed in the same medium never changes. Thus, students need to recognize the properties of electromagnetic waves and know how to read a chart comparing various types and frequencies of electromagnetic waves to each other.
This standard is rather long so I inserted two questions showing two of the four phenomena addressed by this standard. Phenomena concerning light include reflection, refraction, diffraction, and Doppler shift. Students need to understand all of these concepts and how to apply them to a problem. Question 1 addresses reflection and tests students’ knowledge and understanding of the law of reflection: the angle made by the incoming ray equals the angle of the reflected ray. It also tests students’ knowledge of measuring the angle to the normal rather than the surface. Students have to draw their own normal line in here.

The second question addresses students’ knowledge of the concept of refraction. It assesses students understanding of a change in medium and how that connects to the index of refraction. Students have to use the equation n=c/v to correctly answer this question, recognizing that c is the speed of light in a vacuum and v is the new velocity in the medium, represented by n.

24, 25, 26, 27, 31a, 31b, 31c, 32, 33

26. A pencil with a height of 8.0 cm is placed 10.0 cm in front of a converging mirror and its image appears a distance of 20.0 cm behind the mirror. The image’s properties are:

1. Virtual, upright and larger than the object
2. Real, inverted and larger than the object
3. Virtual, inverted and smaller than the object
4. Real, upright, and smaller than the object.

This standard addresses surfaces that are not flat and how light interacts with these surfaces. Curved surfaces include spherical lenses and mirrors. This particular question deals with a spherical mirror that is converging. Students need to know that a concave mirror is a converging mirror and can then use the mirror equations to determine where the image will be located and how large it will be. Having a negative value for focal distance shows that the image will be virtual. Having a negative value for height of the image shows that the image will be inverted. Arriving at a magnification that is greater than 1 shows that the image will be larger than the object.
| OP4: I can identify the significance of optics as it relates to the real world. | *NOTE: this standard was not tested by test and assessment but rather through student’s individual project research and hands-on stations activities where students were able to individually and collectively explore the implications of these applications in a hand-on environment. |
The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

---

Join with this CODE at Nearpod.com or in the app

CZRNH

Valid from Thu, Oct 24th 2019 until Sat, Nov 23rd 2019

29 days remaining

---

Nearpod Reflection Document:

OPTICS REFLECTIONS
Which standard was most difficult for you, based on your assessment score?

- A. OP1
- B. OP2
- C. OP3
- D. OP4

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!

Ready? Enter your answer here.

If you plan to retake a second standard, which one will it be?

- A. OP1
- B. OP2
- C. OP3
- D. OP4
What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard  
B. Meet with Mrs. Carbone to discuss questions  
C. Read topic and answer sample questions on Classroomphysics.com  
D. Create flashcards to memorize terms and units that caused confusion  
E. Watch videos on this topic at khan academy to deepen understanding  
F. Go through notes  
G. Other

What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?

Ready? Enter your answer here.
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of electromagnetic waves and optics and the four standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to apply knowledge of phenomena having to do with light to technologies used in the real world.

This particular project requires students to travel through four stations of various applications of optics. For each station, students will get a taste of how optics applies to the current world but also how the other three standards of this unit are synthesized to create each of the applications studied here. Students will move through four stations of applications. In the first station, students will explore total internal reflection of light in a substance when the light source reaches the critical angle. This station has applications to fiber optics and significantly faster moving processing systems. The second station uses a model of a human eye to help students understand how the eye, in a very simplistic manner, uses lenses that are curved to create an image. Students can then explore what causes myopia and hyperopia and how the lenses in glasses work to correct this vision. The third station allows students to mix colors and use filters, showing the primary colors of light and how adding colors of light actually creates white. Additionally, students will be able to explore polarization of sunglasses and technology equipment as well as how 3D movies are created. Station 4 allows students to create their own microscope/telescope and use the structure to read a hidden message written in very small font on the opposite wall of the room, allowing students to explore the implications of a multiple-lens system.

Completing this project requires students to address each of the four standards associated with waves. These standards will be addressed not only and how they create their own instrument and the sound that it makes but also in their written reflection addressing each of the concepts. The depth of learning is significantly increased when students can apply that learning directly to an application.

| OP1 | ______/5 |
| OP2 | ______/5 |
| OP3 | ______/5 |
| OP4 | ______/5 |
| TOT | ______/20 |
**Station 1 – Total Internal Reflection**

1. Place the trapezoidal piece of Lucite on your basic optics ray table with the angled side perpendicular to the normal line.

2. Using one beam of light, create an incident ray with an angle of incidence of 30 degrees. On the right make a sketch of all the light rays you see! Be as detailed as possible, include light rays inside the Lucite!

3. Label each ray as being due to refraction or reflection.

4. Using one of the refracted rays inside the Lucite, determine the angle of refraction and index of refraction of Lucite. Compare to the accepted value and compute your percent error.

5. Now, slowly move your beam of light back towards the normal line (angle less than 30 degrees) until you get total internal reflection (no refracted beam!). What angle did this occur at?

6. As you moved your light, what phenomenon did you see occurring in the refracted ray (hint: did you see any colors)?

7. Determine the speed of light in Lucite:

8. The wavelength of a light beam in Lucite is 450 nm. What would the wavelength of this light be in water?
Station 2 – Eye Model

1. Place your eye model on the stack of books facing the outside. Make sure the white “retina” screen is in the slot labelled normal. What do you see on the screen? What kind of an image is formed? (real, virtual, inverted, upright?)

Draw a cool (but quick!) picture on a piece of paper.

2. Place the 400 mm lens inside the slot labelled “septum.” Using the lamp, illuminate your picture and hold the picture in front of the lens (about 50 cm away).
   a. Describe what you see:
   b. Is this lens converging or diverging? Does this make sense?

3. Fill your eye model with water. Place the 400 mm lens in the septum slot and the 62 mm lens in the “B” slot. Place the light source in front of the eye and move it until the image is in focus.
   a. Measure the distance between the lenses and the light source:
   b. Measure the distance between the lenses and the retina:
   c. Determine the focal length of your lens system. How is this related to the focal lengths of the lenses?

4. Move the retina screen to the “near” position. Is your image out of focus? Find a lens to place in front of the eye that makes it more in-focus. What lens did this? Does this make sense?

5. Move the retina screen to the “far” position. Is your image out of focus? Find a lens to place in front of the eye that makes it more in-focus. What lens did this? Does this make sense?
Station 3 – Mixing of Colors/Polarization

1. Use the color mixer to project all three colors onto the white sheet of paper. Below, make a sketch of what you see and explain the color combinations you see in terms of reflection of light:

2. Using the colored filters, hold them in front of the color mixer and record your observations below. Explain each in terms of absorption and reflection of light!
   a. Yellow:
   b. Blue:
   c. Green:
   d. Red:

3. Determine the wavelength of colored light for each of the colors above:

4. Fill the beaker halfway to the top with water. Cover one eye with your hand and pour the water into the graduated cylinder. What do you observe? Why?

5. Power up one of the computers. Using the polarizers, is there an angle you can hold it in front of the computer in order to block the light? Explain.
Station 4– Build your own microscope

Build a large-scale microscope with multiple lenses and analyze the function of a microscope by reading fine-print messages to determine the magnification of the microscope.

Materials: 250 mm convex lens, 100 mm convex lens, Red Laser

Procedure:
1. Place the red laser at the end of the track and turn the laser on. BE CAREFUL! Be sure that no one is in front of the laser. NEVER look directly at the laser or aim it at a person.
2. Using the 250 mm lens as the objective lens and the 100 mm lens as the eyepiece lens, find a position for both lasers that will focus the laser on the wall opposite you.
3. Remove the laser and turn it off. Look through the set of lenses and try to read the words taped on the wall opposite your station. You may need to make some fine-tuning adjustments to the lenses.
4. Once you can read the message, write the message here:

5. Record your word on the crossword puzzle on the board!

6. Is the image produced by the objective lens real or virtual? Inverted or upright? Larger or smaller?

Challenge Analysis: With your group, determine what measurements and calculations you would need to made to determine the magnification of your lens system. Then do them on a blank sheet.
Re-take Assessment for Module #3: Electromagnetic Waves

Name: ________________
Quest Unit 3: Optics REATKE

**OP1**

1. An ultraviolet photon and a radio wave photon are traveling in a vacuum. Compared to the frequency and energy of the ultraviolet photon, the radio wave photon has a
   1. Higher frequency and more energy
   2. Lower frequency and more energy
   3. Higher frequency and less energy
   4. Lower frequency and less energy
   5. Same frequency and same energy

2. An electromagnetic AM-band radio wave could have a wavelength of
   1. 0.005 m
   2. 3. 500 m
   3. 2.5 m
   4. 4. 5 000 000 m

3. Compared to the speed of a sound wave in air, the speed of a radio wave in air is
   1. less
   2. greater
   3. the same

4. Compared to the period of a x-ray, the period of a microwave is
   1. less
   2. greater
   3. the same

5. Which color of light has a wavelength of 5.5x10⁻⁷ meter in air?
   1. blue
   2. green
   3. orange
   4. yellow

6. An electromagnetic wave is produced by charged particles vibrating at a rate of 4.5 x 10²⁵ vibrations per second. The electromagnetic wave is classified as what type of wave?
   1. a microwave
   2. an infrared wave
   3. a gamma ray
   4. visible light

7. Radio waves diffract around buildings more than visible light waves do because, compared to light waves, radio waves
   1. move faster
   2. move slower
   3. have a higher frequency
   4. have a longer wavelength

8. Which pair of terms best describes light waves traveling from the Sun to Earth?
   1. electromagnetic and transverse
   2. electromagnetic and longitudinal
   3. mechanical and transverse
   4. mechanical and longitudinal

A 1.80 x 10⁻⁶ meter-long segment of an electromagnetic wave is represented below.


10. Calculate the wavelength in a vacuum of a wave having a frequency of 2.2 x 10⁹ hertz. SHOW YOUR WORK! [2]
1. What is the speed of light \( f = 5.09 \times 10^{14} \text{ Hz} \) in flint glass?

2. ______ A car’s horn produces a sound wave of constant frequency. As the car speeds up going away from a stationary spectator, the sound wave detected by the spectator
   1. decreases in amplitude and decreases in frequency
   2. decreases in amplitude and increases in frequency
   3. increases in amplitude and decreases in frequency
   4. increases in amplitude and increases in frequency

3. ______ If monochromatic light undergoes diffraction, which characteristic of the light will remain the same?
   1. Frequency
   2. Speed
   3. Wavelength
   4. Direction

4. ______ A light ray traveling in air enters a second medium and its speed slows to 1.71 \( \times \) 108 meters per second. What is the absolute index of refraction of the second medium?
   1. 1.00
   2. 0.570
   3. 1.75
   4. 1.94

5. ______ A beam of monochromatic light travels through flint glass, crown glass, Lucite, and water. The speed of the light beam is fastest in
   1. flint glass
   2. Lucite
   3. crown glass
   4. water

6. ______ What happens to the speed and frequency of a light ray when it passes from air into water with an angle incidence of 15°?
   1. The speed decreases and the frequency increases.
   2. The speed decreases and the frequency remains the same.
   3. The speed increases and the frequency increases.
   4. The speed increases and the frequency remains the same.

7. ______ A radar gun can determine the speed of a moving automobile by measuring the difference in frequency between emitted and reflected radar waves. This process illustrates
   1. Resonance
   2. Diffraction
   3. The Doppler effect
   4. Refraction

8. ______ A wave passes through an opening in a barrier. The amount of diffraction experienced by the wave depends on the size of the opening and the wave’s
   1. Amplitude
   2. Wavelength
   3. Velocity
   4. Phase

9. ______ A car’s horn is producing a sound wave having a constant frequency of 350 hertz. If the car moves toward a stationary observer at constant speed, the frequency of the car’s horn detected by this observer may be
   1. 320 Hz
   2. 330 Hz
   3. 350 Hz
   4. 380 Hz

10. How much time does it take light from a lightning bolt to reach you if the storm is 1500 meters away?
Name: ____________________________
Quest Unit 3: Optics REATKE

A ray of monochromatic yellow light \((f = 5.09 \times 10^{14} \text{ Hz})\) passes from water through flint glass and into medium \(X\), as shown to the right.

![Diagram of light ray passing through media]

11. The absolute index of refraction of medium \(X\) is
   1. less than 1.33
   2. greater than 1.33 and less than 1.52
   3. greater than 1.52 and less than 1.66
   4. equal to 1.66

12. If the wavelength of the light beam in the water is \(5.8 \times 10^{-8} \text{ m}\), what is its new wavelength in flint glass?

13. In which way does blue light change as it travels from diamond into crown glass?
   1. Its frequency decreases.
   2. Its speed decreases.
   3. Its frequency increases.
   4. Its speed increases.

14. What is the angle between this light ray and its reflected ray?
   1. 30°
   2. 60°
   3. 120°
   4. 150°

**Use the following to solve questions 13 and 14.**
A light ray with a frequency of \(5.09 \times 10^{14} \text{ hertz}\) traveling in water has an angle of incidence of 35° on a water-air interface. At the interface, part of the ray is reflected from the interface and part of the ray is refracted as it enters the air.

15. Identify one characteristic of this light ray that is the same in both the water and the air.

16. Calculate the angle of refraction of the light ray as it enters the air.

17. Which opening will cause the greatest diffraction?
Name: ____________________________  
Quest Unit 3: Optics REATKE

18. Which diagram best represents the behavior of a ray of monochromatic light in air incident on a block of crown glass?

![Diagrams of light rays](image)

A light ray \((f = 5.09 \times 1014 \text{ Hz})\) is refracted as it travels from water into flint glass. The path of the light ray in the flint glass is shown in the diagram below.

19. Identify one physical event, other than transmission or refraction that occurs as the light interacts with the water-flint glass boundary.

![Diagram of light rays](image)

20. Calculate the angle of incidence for the light ray in water. [Show all work, including the equation and substitution with units.]

21. On the diagram, using a protractor and a straightedge, draw the reflected ray. What is the angle of reflection of the light ray at the interface?
OP3

Use the following information and image to answer questions 1-4

In the diagram, a 20 cm tall pencil is placed 50 cm away from a converging lens with a focal length of 20 cm. Using either a ray diagram, mathematics, or your own knowledge, determine:

1. The location of the image. [1]

2. The height of the image. [1]

3. Whether the image is real or virtual. [1]

4. Whether the lens is concave or convex. [1]
5. Draw ray diagrams below to locate the image produced: [4]

6. A pencil 0.10 meter long is placed 1.0 meter in front of a concave (converging) mirror whose focal length is 0.50 meter. The image of the pencil is

   1. upright and 0.030 meter long
   2. upright and 0.10 meter long
   3. inverted and 0.030 meter long
   4. inverted and 0.10 meter long

6
7. A convex side view mirror with a focal length of 150 cm is used to view a car 6 m away from the mirror in another lane. The image of the car produced by the mirror is
   1. real and inverted
   2. real and upright
   3. virtual and inverted
   4. virtual and upright

8. A rubber duck sits 2 meters in front of a plane mirror. The reflected image of the rubber duck is most likely
   1. On the same side as the rubber duck and 2 meters from the mirror
   2. On the opposite side of the mirror as the rubber duck and 2 meters away
   3. At the focal point, 4 meters from the mirror on the same side as the duck
   4. At the focal point, 4 meters from the mirror on the opposite side as the duck

9. When parallel light rays are shined on a convex mirror, the rays converge:
   1. In real space and at the focal point
   2. In virtual space and at the focal point
   3. In real space and at the center of convergence
   4. In virtual space and at the center of convergence

10. A flower is placed 0.65 meter in front of a converging mirror that has a focal length of 0.37 meter. How far from the mirror is the image of the flower located?

11. A candle is placed 0.24 meter in front of a converging mirror that has a focal length of 0.12 meter. How far from the mirror is the image of the candle located?
   1. 0.08 m
   2. 0.12 m
   3. 0.24 m
   4. 0.36 m
Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades a listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
<thead>
<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Waves and Optics:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>OP1a</th>
<th>OP1b</th>
<th>OP2a</th>
<th>OP2b</th>
<th>OP3a</th>
<th>OP3b</th>
<th>OP4a</th>
<th>OP4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL POINTS</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>student A</td>
<td>2.0</td>
<td>4.0</td>
<td>3.5</td>
<td>4.0</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student B</td>
<td>3.0</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student C</td>
<td>2.0</td>
<td>3.0</td>
<td>2.0</td>
<td>3.0</td>
<td>2.0</td>
<td>3.5</td>
<td>1.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
### NYS Physics Standard:

<table>
<thead>
<tr>
<th>Title</th>
<th>Unit 4: Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source/website</td>
<td>Created by E. Carbone 10/1/19</td>
</tr>
</tbody>
</table>

**Key Ideas:**

**PS3.A: Definitions of Energy:** These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

**PS3.A: Definitions of Energy:** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

**PS3.B: Conservation of Energy and Energy Transfer:** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

**PS3.B: Conservation of Energy and Energy Transfer:** Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

**PS3.B: The availability of energy limits what can occur in any system.** (HS-PS3-1)

**PS3.B: Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).** (HS-PS3-4)

**PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

**PS3.D: Energy in Chemical Processes:** Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy.

### Supplies

- Energy Standards one-pager
- List of standards paired with “I can” statements and standard codes
- Unit Test: Energy (bubble sheet, test booklet, answer key, questions sorted by standard)
- Energy Test Retake (test booklet with questions sorted by standard, answer key)
- Sample student feedback score sheet
Summary:
This unit on energy is an excellent introduction for students into energy transfers and energy conservation. Students have some prior knowledge of energy from their chemistry classes, where they talk about various forms of energy being converted into heat or light on a very basic level. These discussions were centered specifically on exciting electrons and heating and cooling curves. In physics, we will expand students understanding of energy conservation's to a much more broad variety of forms of energy and true multiple different energy conversions within a system.

Students already have an understanding of conservation of energy. As any unit, the first step in teaching energy is allowing students to reflect on what they already know. Questions will be asked to students such as: Why does a pasta bake heat up in the oven? How did lights turn on? Why can a car accelerate? How do you walk up stairs? These questions will allow students the opportunity to determine energy transfer is happening in their everyday lives. We will then begin to categorize types of energy to various energy forms and discuss energy transfer further. Specifically we will discuss kinetic energy, potential energy due to gravity, potential energy due to a spring, chemical energy, electrical energy, and energy lost to friction. The most challenging aspect of this unit for students is calculating work done by friction in an energy conservation problem. Investigating power is also a significant part of this unit, or the energy utilized in an amount of time.

This unit will be supported by various conceptual activities for students will explore energy transfer on their own. The first of which is a stations activity with various simple energy transfers, a candle burning, a radio playing, etc. where students will be able to investigate the types of energy being transferred from one form to another and create models. Students will also create their own roller coasters to demonstrate kinetic to potential energies. Additionally, students will look at spring potential energy and study energy conservation and transfer in spring toys that bounce off the table as well as a force on a spring lab with masses. This unit will culminate with students completing an egg drop project, will they will calculate the potential energy of an egg as it falls a distance of 5 meters.

The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standards: Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard:</td>
</tr>
<tr>
<td>WE1</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>WE1</td>
</tr>
<tr>
<td>WE3</td>
</tr>
<tr>
<td>WE4</td>
</tr>
<tr>
<td>WE5</td>
</tr>
<tr>
<td>WE6</td>
</tr>
</tbody>
</table>

Additional Notes

At this point in the year, after a variety of topics have been taught, it is necessary to cycle back to previously learned standards to be sure that students have fully internalized standards and can recall information. Furthermore, it is also now relevant to include problems on the assessments that combine knowledge across standards. These problems help students to realize the interconnectedness of physical concepts and avoid the misconception that physics is segmented into units just as they are taught in school. These cross-unit standards problems tend to be more challenging for students because they require them to access their long term memory and also to use extensive problem solving methods to decipher which previous knowledge is necessary for completing the problem at hand. For that reason, a new standard has been added to each of the units following and including unit 4, energy. The following is the standard and knowledge check:

<table>
<thead>
<tr>
<th>Standards: Cross-Standard Review</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard:</strong></td>
</tr>
<tr>
<td>Z1 Requisite Knowledge and connections</td>
</tr>
</tbody>
</table>
concepts and skills and can use these skills to solve a problem involving multiple steps and standards across units.

**Possible Misconceptions:**
Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery of Energy concepts that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from New York Science Teacher: Physics Misconceptions, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Topic</th>
<th>Possible Common Misconceptions:</th>
</tr>
</thead>
</table>
| WE1      | Work  | - Energy is a thing. This is a fuzzy notion, probably because of the way we talk about newton-meters or joules. It is difficult to imagine an amount of an abstraction.  
- The terms “energy” and “force” are interchangeable.  
- Energy can be changed completely from one form to another without energy loss.  
- There is no relationship between matter and energy.  
- Believing that any force times any distance is work.  
- Believing that machines put out more work than we put in.  
- Not realizing that machines simply change the form of work we do and trade off force for distance or distance for force. |
| WE1      | Power | - Energy is confined to some particular origin, such as what we get from food or what the electric company sells.  
- From the non-scientific point of view, “work” is synonymous with “labor.” It is hard to convince someone that more work is probably being done playing basketball for 30 minutes than studying for a test. |
| WE3      | Potential Energy | - The terms “energy” and “force” are interchangeable.  
- The only type of potential energy is gravitational.  
- Gravitational potential energy depends only on the height of an object. |
<table>
<thead>
<tr>
<th>WE4</th>
<th>Kinetic Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An object at rest has no energy.</td>
</tr>
<tr>
<td></td>
<td>Doubling the speed of a moving object doubles the kinetic energy.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WE5</th>
<th>Conservation Of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy is a thing. This is a fuzzy notion, probably because of the way we talk about newton-meters or joules. It is difficult to imagine an amount of an abstraction.</td>
</tr>
<tr>
<td></td>
<td>Energy can be changed completely from one form to another without energy loss.</td>
</tr>
<tr>
<td></td>
<td>Things “use up” energy.</td>
</tr>
<tr>
<td></td>
<td>Energy is truly lost in many energy transformations.</td>
</tr>
<tr>
<td></td>
<td>If energy is conserved, why are we running out of it?</td>
</tr>
<tr>
<td></td>
<td>Believing that machines put out more work than we put in.</td>
</tr>
<tr>
<td></td>
<td>Not realizing that machines simply change the form of work we do and trade off force for distance or distance for force.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WE6</th>
<th>Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An object at rest has no energy.</td>
</tr>
<tr>
<td></td>
<td>The only type of potential energy is gravitational.</td>
</tr>
</tbody>
</table>
Appendix of Supplemental Materials for Module Kit #4

Test for Module #4: Energy

Name: ___________________________  Period: _____

Unit 4 Exam:

   Energy

Directions:

* Mark multiple choice questions on the separate answer sheet. Only answers marked on the answer sheet will be scored.
* Write your responses to extended-response questions on the separate answer sheet. Only answers marked on the answer sheet will be scored. Use complete sentences and proper grammar when appropriate.
* Show ALL work for calculations in FSA format.
* You may use the References Tables for Physical Setting / Physics as well as a pen/pencil, ruler, protractor, and scientific calculator on this exam
1. Complete the following chart: [2]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td></td>
</tr>
<tr>
<td>Displacement</td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
</tr>
<tr>
<td>Momentum</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
</tr>
</tbody>
</table>

2. A soccer player having less mass than the runner also accelerates uniformly from rest to a speed of 8.00 meters per second. Compare the kinetic energy of the less massive soccer player to the kinetic energy of the more massive runner when both are traveling at the same speed. [1]

Use the following information to answer questions 16-17 A 3-kg ball rolls down a frictionless hill with the profile below. It starts at rest at point A.

3. Fill in the potential, kinetic, and total energy of the ball at the following points: [3]

<table>
<thead>
<tr>
<th>Point</th>
<th>Potential Energy (J)</th>
<th>Kinetic Energy (J)</th>
<th>Total Energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Will the ball reach point H? Defend your answer with evidence or explanation [1]
Base your answer to questions 5-6 on the information below.

A boy pushes his wagon at constant speed along a level sidewalk. The graph below represents the relationship between the horizontal force exerted by the boy and the distance the wagon moves.

![Force vs. Distance graph]

5. What is the total work done by the boy in pushing the wagon 4.0 meters? [1]
   1. 5.0 J
   2. 7.5 J
   3. 120 J
   4. 180 J

6. As the boy pushes the wagon, what happens to the wagon's energy? [1]
   1. Gravitational potential energy increases.
   2. Gravitational potential energy decreases.
   3. Internal energy increases.
   4. Internal energy decreases.

7. A truck weighing 4000 N was driven up a hill that is 60 m above the starting point. If the trip took 50 seconds, what was the minimum power required? [1]
   1. 240,000 W
   2. 12,000,000 W
   3. 4800 W
   4. 3333 W
8. What is the maximum speed to which a motor having a power rating of 20.4 watts can lift a stone weighing 49 N? [1]

1. 0.416 m/s
2. 999.9 m/s
3. 2.40 m/s
4. 4.08 m/s

9. Two objects, A and B, are held one meter above the horizontal ground. The mass of B is twice as great as the mass of A. If PE is the gravitational potential energy of A relative to the ground, then the gravitational potential energy of B relative to the ground is [1]:

1. PE
2. 2PE
3. 4PE
4. ½ PE

Base your answer to questions 10-11 on the information below.

A 75-kg student is at rest in a 250-kg cart at the top of a 30 meters hill (point A). In front of her is a shorter hill with a height of 10 meters (point C).

10. Rank the velocities at points A, B, & C from smallest to largest: [1]

1. A < B < C
2. C < B < A
3. A < C < B
4. B < C < A

11. Calculate the velocity of the student-cart system at point C: [1]

1. 392 m/s
2. 19.8 m/s
3. 24.3 m/s
4. 14.0 m/s
12. The diagram to the right represents a 35-newton block hanging from a vertical spring, causing the spring to elongate from its original length. Determine the spring constant of the spring. [1]
   1. 3.5 N/m
   2. 140 N/m
   3. 8.75 N/m
   4. 350 N/m

13. Which graph best represents the relationship between the potential energy stored in a spring and the change in the spring’s length from its equilibrium position? [1]

14. A vertically hung spring has a spring constant of 150. newtons per meter. A 2.00-kilogram mass is suspended from the spring and allowed to come to rest. Calculate the elongation of the spring produced by the suspended 2.00-kg mass [2]:

15. A jack-in-the-box is a toy in which a figure in an open box is pushed down, compressing a spring. The lid of the box is then closed. When the box is opened, the figure is pushed up by the spring. The spring in the toy is compressed 0.070 meter by using a downward force of 12.0 Newtons.
   a. Calculate the total amount of elastic potential energy stored in the spring when it is compressed. [1]

   b. Identify one form of energy to which the elastic potential energy of the spring is converted when the figure is pushed up by the spring (other than internal energy). [1]
Use the information below to answer questions 16-19
A 15-kg box slides down a ramp with an initial velocity of 2 m/s. The ramp is 10 meters long and the box has maximum vertical height of 3 meters.

16. What is the potential energy of the box at its maximum height of 3 meters? [2]

17. What is the maximum speed of the box at the bottom of the ramp (without friction) [2]

18. If the actual speed of the box was 5 m/s, how much work is done by friction on the box? [2]


20. Kylo Ren (mass of 100kg) applies a 500 N force using “The Force” on a rebel soldier with a mass of 65 kg initially moving at 3.7 m/s in order to bring him to rest. How much time will it take for Kylo Ren to stop the soldier? [2]

21. A 65-kg running back running at 1.2 m/s east collides with a stationary 100-kg lineman. The two players stick together after the collision. What is the speed of the two players afterwards? [2]
## TEST SCORE BREAKDOWN BY STANDARD

**Student:** Example A  
**Assessment:** Unit 4 Energy

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Test Answer</th>
<th>Student Answer</th>
<th>Correct</th>
<th>Points Earned</th>
<th>Out Of</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>WE1 Work: I can determine the work by a force on an object.</td>
<td>3</td>
<td>3</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>WE1 Work: I can determine the work by a force on an object.</td>
<td>3</td>
<td>3</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>WE1 Work: I can determine the work by a force on an object.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>WE2 Power: I can determine the rate at which energy is used.</td>
<td>3</td>
<td>3</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>WE2 Power: I can determine the rate at which energy is used.</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>WE3 Potential Energy: I can determine the energy of a system based on its configuration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>WE3 Potential Energy: I can determine the energy of a system based on its configuration.</td>
<td>2</td>
<td>2</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>WE3 Potential Energy: I can determine the energy of a system based on its configuration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>WE4 Kinetic Energy: I can determine the energy of a system based on its motion.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>WE5 Conservation of Energy: I can apply the conservation of energy to systems where energy changes forms or where work is done.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>WE5 Conservation of Energy: I can apply the conservation of energy to systems where energy changes forms or where work is done.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>WE5 Conservation of Energy: I can apply the conservation of energy to systems where energy changes forms or where work is done.</td>
<td>3</td>
<td>3</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>WE6 Conservation of Energy: I can apply the conservation of energy to systems where energy changes forms or where work is done.</td>
<td>2</td>
<td>2</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>WE6 Conservation of Energy: I can apply the conservation of energy to systems where energy changes forms or where work is done.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>WE6 Springs: I can determine the energy stored in a spring and the force needed to deform it.</td>
<td>4</td>
<td>1</td>
<td>No</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>WE6 Springs: I can determine the energy stored in a spring and the force needed to deform it.</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>WE6 Springs: I can determine the energy stored in a spring and the force needed to deform it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15a</td>
<td>WE6 Springs: I can determine the energy stored in a spring and the force needed to deform it.</td>
<td>1</td>
<td>2</td>
<td>No</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>15b</td>
<td>WE6 Springs: I can determine the energy stored in a spring and the force needed to deform it.</td>
<td>1</td>
<td>3</td>
<td>No</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Z1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>Z1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>Z1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

**Your Score:** 25 out of 34  
**Percent Score:** 73.53%  
**Proficiency Level:**
Standard Questions linked to Standard

<table>
<thead>
<tr>
<th>Standard</th>
<th>Questions linked to Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW1: I can determine the work by a force on an object.</td>
<td>5, 6, 19</td>
</tr>
</tbody>
</table>

5. What is the total work done by the boy in pushing the wagon 4.0 meters? [1]

1. 5.0 J
2. 7.5 J
3. 120 J
4. 180 J

This question requires students to recognize that, since the work done on an object can be found by calculating force \( \times \) distance, you can find the work based on the graph by calculating the area under the line during the distances the problem asks for.

MW2: I can determine the rate at which... | 7, 8 |
### Energy is Used

#### 7.
A truck weighing 4000 N was driven up a hill that is 60 m above the starting point. If the trip took 50 seconds, what was the minimum power required? [1]

1. 240,000 W
2. 12,000,000 W
3. 4800 W
4. 3,333 W

The rate at which work is done, or the amount of work done in a certain amount of time, is the definition of power. Finding the power in the situation given above requires students to find the work done by the truck up the hill (force * distance) and then solve for the power by dividing that value by the amount of time it took the truck to get up the hill.

### MW3:
I can determine the energy of a system based on its configuration.

#### 2, 9, 16

#### 9.
Two objects, A and B, are held one meter above the horizontal ground. The mass of B is twice as great as the mass of A. If PE is the gravitational potential energy of A relative to the ground, then the gravitational potential energy of B relative to the ground is [1]:

1. PE
2. 2PE
3. 4PE
4. \( \frac{1}{2} PE \)

The energy in the above scenario needs to be calculated based on the recognition that the objects have potential energy due to gravity based on their heights. To solve this problem, students need to recognize the factors that determine potential energy and to compare these factors for two objects of various masses, recognizing that mass is directly proportional to energy based on configuration.

### MW4:
I can determine the energy of a system based on its motion.

#### 17

17. What is the maximum speed of the box at the bottom of the ramp (without friction) [2]

The energy in a system due to motion is the definition for kinetic energy. Thus, for this problem, students will need to use their knowledge of the kinetic energy formula to solve for the rate of the motion of this box at the bottom of the hill.

### MW5:
I can apply the conservation of energy to systems where energy changes forms or

#### 3, 4, 10, 11, 18

A 75-kg student is at rest in a 250-kg cart at the top of a 30 meters hill (point A). In front of her is a shorter hill with a height of 10 meters (point C).
where work is done.

<table>
<thead>
<tr>
<th>11. Calculate the velocity of the student-cart system at point C: [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 392 m/s</td>
</tr>
<tr>
<td>2. 19.8 m/s</td>
</tr>
<tr>
<td>3. 24.3 m/s</td>
</tr>
<tr>
<td>4. 14.0 m/s</td>
</tr>
</tbody>
</table>

Conservation of energy is necessary to complete this problem. Students need to recognize that they can find the total energy of the system by finding the potential energy of the cart at the top of the hill. They will then need to use this value to find the kinetic energy at the bottom of the hill by setting the total energy at the top equal to the total energy at the bottom, thus noting an understanding of conservation of energy.

<table>
<thead>
<tr>
<th>MW6: I can determine the energy stored in a spring and the force needed to deform it.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12, 13, 14, 15a, 15b</td>
</tr>
</tbody>
</table>

15. A jack-in-the-box is a toy in which a figure in an open box is pushed down, compressing a spring. The lid of the box is then closed. When the box is opened, the figure is pushed up by the spring. The spring in the toy is compressed 0.070 meter by using a downward force of 12.0 Newtons.

a. Calculate the total amount of elastic potential energy stored in the spring when it is compressed. [1]

In order to solve this problem, students need to recognize that there is energy stored in the spring due to the spring constant in the spring as well as the distance it is compressed. Given the force and compression of the spring, students can find the spring constant and then use that value, along with the compression, to find the amount of energy stored in the spring.

<table>
<thead>
<tr>
<th>Z1: Requisite Physics Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 20, 21</td>
</tr>
</tbody>
</table>

These questions address information covered in previous units and require students to draw on their requisite knowledge from either other physics units or previous math units.
The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Nearpod Reflection Document:
Which standard was most difficult for you, based on your assessment score?

- A. WE1
- B. WE2
- C. WE3
- D. WE4
- E. WE5
- F. WE6

Select an answer

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!

Ready? Enter your answer here.
If you plan to retake a second standard, which one will it be?

A. WE1
B. WE2
C. WE3
D. WE4
E. WE5

What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard
B. Meet with Mrs. Carbone to discuss questions
C. Read topic and answer sample questions on Classroomphysics.com
D. Create flashcards to memorize terms and units that caused confusion
E. Watch videos on this topic at Khan Academy to deepen understanding
F. Go through notes
G. Other
What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?

Ready? Enter your answer here.
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of energy the six standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to the creation and evaluation of their own egg drop container.

This particular project requires students to create their own container to carry two eggs to safety after being dropped from a 2 meter high fall. In addition to the extra egg students have to protect, the other component of their project that makes it exceptionally unique and complicated is the limiting of resources for students. Students will be given a budget and their projects will be graded not only on whether or not their egg survives but also on how little of their budget they were able to use. Students will have to plan how much of the money they should spend in building in addition to what supplies to use that will be most worth their money.

At the conclusion of students’ planning and building process, the eggs and containers will be dropped. Students will collect data from these drops and film the drop in order to write conclusions both about the physics, having to do with energy and forces, as well as their construction. Students will consider the amount of energy their project has at the top of the drop as well as the amount of velocity is has when it meets the ground below. They will also look into the amount of energy lost along the fall, to air resistance, and how much was protected from the floor.

Completing this project requires students to recognize the methods of creating a lower velocity for the eggs as they hit the floor below. It also requires students to consider which materials will provide the best structure and cushioning for the eggs. All of this time, students will be considering the cost of the materials and be forces to carefully plan, thus giving them a good idea of what a realistic engineering project may look like. Students will demonstrate what they have learned in the write up and analysis questions following the drop.

---

**Eggs Drop Challenge**

**Group Objective:** Design, defend, and implement a solution to the problem of bringing TWO eggs safely to rest when dropped from a height of 2.5 meters.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WE1/2</td>
<td>_____/5</td>
</tr>
<tr>
<td>WE3/4</td>
<td>_____/5</td>
</tr>
<tr>
<td>WE5</td>
<td>_____/5</td>
</tr>
<tr>
<td>Z1</td>
<td>_____/5</td>
</tr>
<tr>
<td>TOT</td>
<td>_____/20</td>
</tr>
</tbody>
</table>
**Group**: Your group must consist of a minimum of 2 persons and a maximum of 4.

**Group names**: _____________________________________________________

**Outline of Tasks:**

1. **Grant Proposal**: Write a small grant outlining your design in detail in order to obtain materials (within a budget of $200 Carbucks). Before submitting your grant, you may look but not touch, test, or experiment with the materials. You must defend your design and materials using scientific concepts surrounding momentum and impulse. Before construction, your design must be accepted by the instructor.

2. **Design Implementation**: Here you will build and test your design using only the materials obtained from your grant. Deviations at this stage from your proposed design are allowed, but will cost your team some points. No “trial runs” are permitted before your final test.

3. **Solution Testing**: When you are ready to complete the official test, get permission from Mrs. Street and test your eggs drop solution in the space provided. **Film your test with a slow-motion camera.** Some points are deducted for unexpected passenger(s) disassembly (egg breaking).

4. **Debrief**: Following your test and analyzing the film evidence from your egg drop and the data you collected to complete the lab questions following in the debrief.

5. **Bonus Challenge**: You may revise your design and retest using more materials / different egg, regardless of whether your initial test was successful or not. A short write-up of your rationale and results must accompany the bonus.

**Deliverables**: A grant proposal, Egg container (with video), debrief sheet, and self-assessment rubric from each group.

**Rules:**

1) The egg must be removable so that it can be tested to make sure it is not compressed and to check for cracks at the end.

2) You may only use the materials provided and must purchase everything that you use.

3) Do not spend more than $250.

4) There are no returns!

5) You must record the time of the fall and the mass of the egg/container.
Winners:

FIRST PLACE: Both Eggs survive the drop + least money spent
SECOND PLACE: 1 Egg Survives the drop + least amount of money spent
THIRD PLACE: Both Eggs survive the drop + second least amount of money spent

Self-Assessment Rubric: Points are awarded or deducted as follows.

<table>
<thead>
<tr>
<th>Grant Proposal</th>
<th>Possible Points</th>
<th>Our Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successfully uses scientific concepts to defend proposal</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Did not test or experiment with materials early</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Includes unique &amp; novel design elements</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Egg Drop Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOTH Eggs survive 2.5 meter drop.</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Spent within the $250 budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filmed using a slow-motion camera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spent least amount of money</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Debrief</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successfully uses scientific concepts to explain success or failure.</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Proposes modification or alternative design for improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses film evidence to support data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group Total: _____/40

Data and Math:
Variables to find **before** or **during** the experiment:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial velocity of container</td>
<td></td>
</tr>
<tr>
<td>Mass of container and eggs</td>
<td></td>
</tr>
<tr>
<td>Height of drop</td>
<td></td>
</tr>
</tbody>
</table>
1. Determine the total energy of the eggs and container before the egg was dropped.

2. Determine the final velocity of the eggs and container just before it hit the ground using kinetic energy and conservation of energy.

3. What was the egg and container’s momentum right before it hit the ground?

4. Determine the force the floor on your container if it was brought to a complete stop in 0.02s.

5. Determine mathematically the time it took your egg to fall. Find the error between your resultant value and the time calculated on the stop watch.

6. Draw a free body diagram of your egg container:
Analysis:

1. Did your eggs survive? If not, explain why not. If so, what did you do to protect it?

2. How did air resistance play a role? How would this effect the time you calculated?

3. Explain why you chose the materials you used for your project. Be sure to include how impulse will play a role in the collision.

4. If you were to complete this challenge again, what are at least 2 things you would change to decrease the cost of your egg container while still functioning to protect the eggs?

5. Would you want your container to bounce off the floor? Explain why or why not?
Re-take Assessment for Module #4: Energy

Name: ____________________________

Unit 4: Energy Test RETAKE

| WE1/2 | /6 |
| WE3/4 | /6 |
| WE5   | /8 |
| WE6   | /8 |
| Z1    | /6 |

WE1/WE2
1. A car weighing 3000 N was driven up a hill that is 30 m above the starting point. If the trip took 40 seconds, what was the minimum power required? [1]

2. What is the maximum speed to which a motor having a power rating of 14 watts can lift a stone with a mass of 2.3 kg? [1]

A boy pushes his wagon at constant speed along a level sidewalk. The graph below represents the relationship between the horizontal force exerted by the boy and the distance the wagon moves.

3. What is the total work done by the boy in pushing the wagon 10.0 meters? [1]

4. As the boy pushes the wagon, what happens to the wagon's energy? [1]

   1. Internal energy increases.
   2. Internal energy decreases.
   3. Gravitational potential energy increases.
   4. Gravitational potential energy decreases.

5. *A 2-kg car slides down a ramp with an initial velocity of 3 m/s. The ramp is 10 meters long and the cart has maximum vertical height of 5 meters. The final velocity of the cart is 9 m/s and the internal energy of the system when the cart is at the bottom is 20 J.

   What is the force of friction acting on the box? [2]
WE3/WE4

1. A little boy lets go of a wagon at the top of a hill. The wagon rolls down the hill at an increasing velocity. Which graph best represents the relationship between the kinetic energy and velocity of the wagon? [1]

2. A 2-kg car slides down a ramp with an initial velocity of 3 m/s. The ramp is 10 meters long and the cart has maximum vertical height of 5 meters and the final velocity of the cart is 9 m/s. What is the potential energy of the cart at its maximum height of 5 meters? [2]

3. A motor does 20 joules of work on a block, accelerating the block vertically upward. Neglecting friction, if the gravitational potential energy of the block increases by 15 joules, its kinetic energy

1. decreases by 5 J
2. increases by 5 J
3. decreases by 35 J
4. increases by 35 J
**WE5**

A 5-kg ball rolls down a frictionless hill with the profile below. It starts at rest at point A.

1. Fill in the potential, kinetic, and total energy of the ball at the following points: [3]

<table>
<thead>
<tr>
<th>Point</th>
<th>Potential Energy (J)</th>
<th>Kinetic Energy (J)</th>
<th>Total Energy (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Will the ball reach point H? Defend your answer with evidence or explanation [1]

A 55-kg student is at rest in a 350-kg cart at the top of a 140 meters hill (point A). In front of her is a shorter hill with a height of 95 meters (point B).

3. Rank the velocities at points A, D, & C from smallest to largest: [1]
   a. $A < B < C$
   b. $A < C < B$
   c. $C < B < A$
   d. $B < C < A$

4. Calculate the velocity of the student-cart system at point B: [1]

A 2-kg car slides down a ramp with an initial velocity of 3 m/s. The ramp is 10 meters long and the cart has maximum vertical height of 5 meters.

5. What is the maximum speed of the cart at the bottom of the ramp (without friction)? [2]

6. If the actual speed of the car was 9 m/s, how much work is done by friction on the box? [2]
1. A jack-in-the-box is a toy in which a figure in an open box is pushed down, compressing a spring. The lid of the box is then closed. When the box is opened, the figure is pushed up by the spring. The spring in the toy is compressed 0.070 meter by using a downward force of 12.0 newtons. Calculate the total amount of elastic potential energy stored in the spring when it is compressed. [Show all work, including the equation and substitution with units.]

2. A vertically hung spring has a spring constant of 60. newtons per meter. A 15-kilogram mass is suspended from the spring and allowed to come to rest.
   a. Calculate the elongation of the spring produced by the suspended 1.15-kg mass [2]:

   b. Calculate the total elastic potential energy stored in the spring due to the suspended 1.15-kg mass [2]

3. A graph showing the force of various sprigs vs. the elongation of the spring is shown below. Based on the graph, which spring (A-D) has the greatest spring constant? ________
Z1
1. Complete the following chart: [2]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td></td>
</tr>
<tr>
<td>Displacement</td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
</tr>
<tr>
<td>Momentum</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td></td>
</tr>
</tbody>
</table>

4. A 65-kg running back running at 1.2 m/s east collides with a stationary 100-kg lineman. The two players bounce apart after the collision. If the lineman has a velocity of 0.5 m/s east, what is the velocity (direction and magnitude) of the running back? [2]

5. A 70 kg student drops a 0.5 kg egg from a height of 3 m onto a soft mat. The egg hits the mat with a velocity of 7.67 m/s and the egg experiences a force of 150 N on the mat. How much time will it take for the egg to come to a complete stop? [2]
Example of Gradebook Snapshot for Module #4: Energy

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student's actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades a listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student's grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
<thead>
<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student's grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Energy:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>WE1</th>
<th>WE2</th>
<th>WE3</th>
<th>WE4</th>
<th>WE5a</th>
<th>WE5b</th>
<th>WE6a</th>
<th>WE6b</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL POINTS</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>student A</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student B</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Student C</td>
<td>2.0</td>
<td>3.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>3.5</td>
<td>2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
# Module Kit #5: Forces

| Title: | Unit 5: Forces |
| Source/website: | Created by E. Carbone 10/8/19 |

## NYS Physics Standard: Key Ideas:
- **PS2.A: Forces and Motion:** Newton’s second law accurately predicts changes in the motion of macroscopic objects.
- **PS2.B: Types of Interactions:** Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- **PS2.B: Types of Interactions:** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
- **PS3.C: Relationship Between Energy and Forces:** When two objects interacting through a field change relative position, the energy stored in the field is changed.

## Supplies
- Force Standards one-pager
- List of standards paired with “I can” statements and standard codes
- Unit Test: Force (bubble sheet, test booklet, answer key, questions sorted by standard)
- Force Test Retake: 1 D Kinematics (test booklet with questions sorted by standard, answer key)
- Sample student feedback score sheet
- Student re-assessment reflection guide

## Summary:
This unit allows students to explore deeper into the forces in their lives. The unit will start with drawings of free body diagrams, teaching students common forces such as normal force, gravitational force, frictional force, and applied force. These forces will be foundational throughout the entire unit and help students understand applications of forces in their lives. Students will use their basic understanding of these forces to solve for the free body diagrams of various objects in the classroom in the first activity. We will then explore Newton's three laws, discussing an object in equilibrium, equal and opposite reactions, and the effects of having a net force on an object. Students will explore the equation F=ma in their daily lives.

Finally, we will discuss the force of friction in greater depth, talking about coefficients of friction and its relation to the normal force. Students will explore the forces of friction on various surfaces with a force activity as well as find the coefficient of friction of their shoe in a second activity. The most challenging aspect of the unit for students is forces on an incline ramp or forces at an angle. In this case students will need to resolve the components of the forces into x and y components, resulting in quite a challenge. Students will attempt to explore this by looking at the forces on a block on a ramp. Other notable activities in this
unit include experiment on mass versus weight and an extensive lab using new scientific equipment and weights on a pulley attached to a cart to prove Newton’s second law to be true. The unit will culminate with a project using flying pig contraptions we’re students will need to use what they have learned to develop a process for calculating the tension force on a pig.

This unit is incredibly relevant for students, as are all units in physics. Forces on an object directly relate to everything that students experience in the daily lives. They will see why it is more difficult to move a shelf that is on a carpet than on the floor and why it is more difficult to get the shelf to start moving and it is to keep it moving. Any student who was involved in sports sees how the forces relate and the movements that they need to make in sports. For example, students will see why cleats provide better traction than sneakers in terms of physics and why running up a hill is more challenging than running on flat ground. Forces dive even deeper into looking at why things balance and how to maintain balance as an athlete.

The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standards: Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard:</strong></td>
</tr>
<tr>
<td>F1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>F2a</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>F2b</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>F3</td>
</tr>
</tbody>
</table>
### Standards: Force

<table>
<thead>
<tr>
<th>Standard</th>
<th>Topic:</th>
<th>Possible Common Misconceptions:</th>
</tr>
</thead>
</table>
| **F1**   | Newton’s First Law | - The only “natural” motion is for an object to be at rest.  
- If an object is at rest, no forces are acting on the object.  
- Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it.  
- A force is needed to keep an object moving with a constant speed.  
- Rocket propulsion is due to exhaust gases pushing on something behind the rocket. |
| **F2a**  | Newton’s Second Law (flat planes) | - Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it.  
- Force is a property of an object. An object has force and when it runs out of force it stops moving.  
- The motion of an object is always in the direction of the net force applied to the object.  
- Large objects exert a greater force than small objects.  
- Failing to be able to identify the direction in which a force is acting. |
| **F2b**  | Newton’s Second Law (inclines and angles) | - Force is a property of an object. An object has force and when it runs out of force it stops moving.  
- Failing to be able to identify the direction in which a force is acting.  
- Failing to evaluate the forces at angles into horizontal and vertical components |
| **F3**   | Friction | - A rigid solid cannot be compressed or stretched.  
- The motion of an object is always in the direction of the net force applied to the object.  
- Friction always hinders motion. Thus, you always want to eliminate friction.  
- Frictional forces are due to irregularities in surfaces moving past each other. |
Appendix of Supplemental Materials for Module Kit #5

Test for Module #5: Forces:

Name: ____________________________  Unit 4: Forces
November 14, 2018  Forces EXAM

Exam: Forces

Directions:

* Mark multiple choice questions on the separate answer sheet. Only answers marked on the answer sheet will be scored.
* Write your responses to extended-response questions on the separate answer sheet. Only answers marked on the answer sheet will be scored. Use complete sentences and proper grammar when appropriate.
* Show ALL work for calculations in FSA format.
* You may use the References Tables for Physical Setting / Physics as well as a pen/pencil, ruler, protractor, and scientific calculator on this exam.
1. State Newton’s 3 Laws [1]
   a. 1st Law:
   b. 2nd Law:
   c. 3rd Law:

2. The mass of a bowling ball is closest to [1]
   a. $7.0 \times 10^{-1}$ kg
   b. $7.0 \times 10^{0}$ kg
   c. $7.0 \times 10^{1}$ kg
   d. $7.0 \times 10^{2}$ kg

3. Which object has the greatest inertia? [1]
   a. A 0.010 kg bullet traveling at 90 m/s
   b. A 30 kg child traveling at 10 m/s on her bike.
   c. A 490 kg elephant walking with a speed of 1.0 m/s.
   d. A 1500-kg car at rest in a parking lot.

4. Which situation represents a person in equilibrium? [1]
   a. A child gaining speed while sliding down a slide.
   b. A woman accelerating upward in an elevator.
   c. A man standing still on a bathroom scale.
   d. A teenager driving around a corner in his car.

5. A 750 N student is standing on a bathroom scale in an elevator car. If the scale reads 400 N, the elevator is moving: [1]
   a. Upward at constant speed.
   b. Upward at an increasing speed.
   c. Downward at constant speed.
   d. Downward at an increasing speed.

6. Two forces act concurrently on an object. Their resultant force has the smallest magnitude when the angle between the forces is [1]
   a. 0°
   b. 30°
   c. 90°
   d. 180°

7. A shoe is at rest on an inclined ramp. As the angle of the incline is increased, the force of static friction: [1]
   a. Increases.
   b. Decreases.
   c. Remains the same.
   d. Equals the kinetic friction.
8. A carpenter hits a 0.15 N nail with a force of 100 N, produced by a 12 N hammer. The force of the nail on the hammer is equal to [1]:
   a. 100 N  
   b. 0.15 N  
   c. 12 N    
   d. 112 N

9. A 4.00 kg object is accelerated at 3.0 m/s² by an unbalanced force. What is the magnitude of this force? [1]
   a. 12 N    
   b. 1.0 N   
   c. 1.3 N   
   d. 0.75 N

10. On a small planet, an astronaut uses a vertical force of 175 N to lift an 87.5 kg boulder at a constant velocity to a height of 0.350 m above the surface. What is the magnitude of the acceleration due to gravity on the surface of the planet? [1]
    a. 0.500 m/s²  
    b. 2.00 m/s²  
    c. 9.81 m/s²  
    d. 61.3 m/s²

11. A car's performance is tested on various horizontal surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the greatest force of friction to stop the car on [1]
    a. Dry concrete  
    b. Dry asphalt  
    c. Wet concrete  
    d. Wet asphalt

**Constructed Response:** Write your work and answers on your separate answer sheet. For calculations, show all work in FSA format. Use complete sentences and proper grammar where appropriate.

12. A 12.0-newton wooden block slides across a horizontal wooden floor at constant velocity. What is the magnitude of the force of kinetic friction between the block and the floor? [2]

13. An ice skater applies a horizontal force to a 20.0 kg block on level ice of negligible friction, causing the block to accelerate uniformly at 1.40 m/s² to the right.
   a. Calculate the magnitude of the force applied to the block by the skater [2]

   b. Draw a Free Body Diagram for the block. Label all forces and calculate the magnitude of each. [2]
14. A 25.0 kg box starting at rest is being pulled across the floor by a rope. A force of 48.0 N is applied through the rope at an angle of 49° above the horizontal. The kinetic force of friction is 11.0 N.

a. What is the net force acting on the block? [2]

b. After what distance will the block reach a final speed of 15 m/s? [2]

15. The diagram below represents a 4.0-newton force applied to a 0.200-kilogram copper block sliding to the right on a horizontal steel table.

![Diagram of the block on the table with a 4.0 N force applied to it.]

a. Calculate the magnitude of the force of friction acting on the moving block. [2]

b. Determine the magnitude of the net force acting on the moving block. [2]
16. An 8.00 N block accelerates from rest down a frictionless ramp inclined at 15° to the horizon.
   a. Draw a free body diagram for the block and determine the net force. Label all forces. [2]

   b. What is the magnitude of the block's acceleration? [2]

   c. What is the velocity of the block after 2.00 seconds? [2]

17. A 20.-Newton force is applied to a 5.0-kg box causing it to accelerate at a rate of 1.0 m/s² across a horizontal floor.
   a. Draw a free body diagram of the box and determine the net force acting on it. [2]

   b. What is the coefficient of friction between the box and the floor? [2]
18. A golf ball is propelled with an initial velocity of 52.0 meters per second at 37° above the horizontal. What are the horizontal & vertical components of the golf ball’s initial velocity? [2]

19. An object is kicked off of a 115 meter high cliff with an initial horizontal velocity of 13.2 m/s.
   
   a) Calculate the time for the projectile to reach the ground. (Ignore Air Resistance) [2]

   b) Calculate the horizontal distance traveled by the projectile. (Ignore Air Resistance) [2]
# TEST SCORE BREAKDOWN BY STANDARD

Student: Example A
Assessment: Unit 5 Forces

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Correct Answer</th>
<th>Student Answer</th>
<th>Correct</th>
<th>Points Earned</th>
<th>Out Of</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F1 Newton’s 1st and Third Laws: I can apply the law of inertia and the law of equal and opposite forces to moving objects.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>F1 Newton’s 1st and Third Laws: I can apply the law of inertia and the law of equal and opposite forces to moving objects.</td>
<td>b</td>
<td>No</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>F1 Newton’s 1st and Third Laws: I can apply the law of inertia and the law of equal and opposite forces to moving objects.</td>
<td>d</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F1 Newton’s 1st and Third Laws: I can apply the law of inertia and the law of equal and opposite forces to moving objects.</td>
<td>c</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td>d</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td>d</td>
<td>No</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td>a</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td>b</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>F2a Newton’s 2nd Law (flat planes): I can apply Newton’s 2nd Law to relate forces and acceleration with free body diagrams.</td>
<td>d</td>
<td>Yes</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13a</td>
<td>F2b Newton’s 2nd Law (inclines and angles): I can apply Newton’s 2nd Law to scenarios involving forces at an angle and inclines.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14a</td>
<td>F2b Newton’s 2nd Law (inclines and angles): I can apply Newton’s 2nd Law to scenarios involving forces at an angle and inclines.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15b</td>
<td>F2b Newton’s 2nd Law (inclines and angles): I can apply Newton’s 2nd Law to scenarios involving forces at an angle and inclines.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16b</td>
<td>F2b Newton’s 2nd Law (inclines and angles): I can apply Newton’s 2nd Law to scenarios involving forces at an angle and inclines.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>17b</td>
<td>F3 Friction: I can predict the motion of an object in an environment with friction.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18b</td>
<td>F3 Friction: I can predict the motion of an object in an environment with friction.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>19b</td>
<td>F3 Friction: I can predict the motion of an object in an environment with friction.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>20b</td>
<td>F3 Friction: I can predict the motion of an object in an environment with friction.</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Newton’s first law states that an object at rest will remain at rest, and an object in uniform motion will remain in that motion until acted on by an outside force. Thus, this is equilibrium, an object being acted on by completely balanced forces. To correctly answer this question, students will need to recognize which station has constant motion and no unbalanced forces.
free body diagrams.

9. A 4.00 kg object is accelerated at 3.0 m/s² by an unbalanced force. What is the magnitude of this force? [1]
   a. 12 N  
   b. 1.0 N  
   c. 1.3 N  
   d. 0.75 N

Newton’s second law states that an unbalanced force on an object will cause it to accelerate based on the mass of the object. Thus, in this particular problem, students will need to use the acceleration and the mass of the object to solve Newton’s second law for force, \( F = ma \).

F2b: I can apply Newton's second Law to scenarios involving forces at an angle and inclines.

7, 14a, 16a, 16b

7. A shoe is at rest on an inclined ramp. As the angle of the incline is increased, the force of static friction: [1]
   a. Increases.  
   b. Decreases.  
   c. Remains the same.  
   d. Equals the kinetic friction.

This standard applies newton’s second law strictly to incline planes and angled problems, where students need to resolve a force into components in the both the horizontal and vertical directions. In this case, students will need to recognize how the forces on a shoe will change as the gravitational force pulling the shoe down the ramp increases.

F3: I can predict the motion of an object in an environment with friction.

11, 12, 15a, 17b

11. A car’s performance is tested on various horizontal surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the greatest force of friction to stop the car on [1]
   a. Dry concrete  
   b. Dry asphalt  
   c. Wet concrete  
   d. Wet asphalt

This questions tests whether students recognize the various components that relate to the frictional force on an object. This force is related to the normal force on an object as well as the coefficient of friction, which changes based on whether the object is stationary or moving. Students will need to use their knowledge of these coefficients.
of friction to find the material that will encounter the greatest force of friction on the car.

| Z1: Requisite Physics Knowledge | 14b, 16c, 18, 19a, 19b |
Independent Student Reflection Document for Module #5: Forces

The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Nearpod Reflection Document:

FORCES REFLECTIONS
Which standard was most difficult for you, based on your assessment score?

- A. F1
- B. F2a
- C. F2b
- D. F3

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!

Ready? Enter your answer here.

If you plan to retake a second standard, which one will it be?

- A. F1
- B. F2a
- C. F2b
- D. F3
What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard
B. Meet with Mrs. Carbone to discuss questions
C. Read topic and answer sample questions on ClassroomPhysics.com
D. Create flashcards to memorize terms and units that caused confusion
E. Watch videos on this topic at Khan Academy to deepen understanding
F. Go through notes
G. Other

What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?

Ready? Enter your answer here.
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of Forces and the standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to the creation and evaluation of their own problem solving methods.

This particular project requires students to create their own investigation into answering a scientific question: Is the force in the string greater when the pig is spinning or at rest? Looking into this phenomenon will Force students to develop their own process for finding the forces acting on the pig. Students’ will be free to any of the schools that they have learned and will often come up with various methods of solving this problem. Students will need to defend the reason they chose the particular method that they did in front of the class. They'll use the data collected as well as their scientific reasoning to support the conclusion that they came to the question. Each group will present their findings, their data as to why and the reasoning for that conclusion. After this time, all students will create a write-up in which they answer the question for themselves based on the group's findings.

Completing this project requires students to address each of the four standards associated with forces. These standards will be addressed not only and how they create their own investigation and reasoning they use to support their findings but also in their written reflection addressing each of the concepts. The depth of learning is significantly increased when students can apply that learning directly to an application.

### Forces Application Project:

**When Pigs Fly:**

**Centripetal Force Inquiry**

**Our Question:** For a flying pig suspended from a line, does the line experience more or less tension when the pig is flying as compared to hanging motionless?
Objective: As a team, develop, document, and carry out a procedure, using your knowledge of centripetal motion and free-body diagrams, to gather data, defend an explanation for your question, and report this answer to the class.

Introduction: Document the physics background needed to develop your procedure and determine the data you will need to collect.

1. What is the free-body diagram for a flying pig hanging motionless?

2. Write an equation for the tension in the line:

3. What is the free-body diagram for a flying pig in uniform circular motion?

4. Write an equation for the tension in the line:

5. Prediction: Which tension will be greater? ______________. Explain:
Procedure: With your group, determine what data you will need to collect in order to defend an explanation for our question and outline what methods you will use to obtain it. (Hint: include a list of what materials you may need and think about what variables you can measure in your equations from the intro).

Results & Data Analysis: Report the results of your investigation, including the data you collected and any data analysis or calculations you have done to solve for a final result.
Discussion & Analysis for this lab you will be:
- Creating a simple poster on your results with your group.
- Crafting a briefing (similar to a lab report introduction) that reports on the physics involved and helps answer the investigation question.

Presentation Guidelines: Your poster must contain:
- A description of your procedure and data collected.
- Your main results with calculations.
- An evaluation of the accuracy of your results.
- A physics explanation answering the question in the lab.

Briefing Guidelines: Your typed or hand-written briefing should contain similar information to a lab report introduction. In it, you should include:
- The research question to be investigated.
- The reasons why you want to investigate this question.
- A physics explanation / background about the topic (circular motion), including variables, equations, and relationships.
- The answer to the question based on the class and your group’s data.

Rubrics for scoring each of these may be found on the back of this page.

Class Data from Presentations:

<table>
<thead>
<tr>
<th></th>
<th>My Data</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension Hanging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tension Flying</td>
<td></td>
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</table>
## Poster Grading Rubric (15 points):

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Max Points</th>
<th>Your Score</th>
</tr>
</thead>
</table>
| **Procedure / Data** | • Provides detailed description of lab procedure  
• Reports data accurately and organized. | 2          |            |
| **Results**      | • Clearly states the results of the investigation in light of the research question.  
• Shows calculations / equations used to find the results. | 4          |            |
| **Analysis**     | • Considers and reports factors that could influence the accuracy and error of the experiment. | 3          |            |
| **Explanation**  | • Provides a physics-based explanation of the research question.  
• Evaluates the accuracy of the initial prediction and revises if necessary. | 2          |            |
| **Work Ethic**   | • Contributions are made from all group members  
• Poster is constructed clearly and professionally. | 4          |            |

## Briefing Grading Rubric (10 points):

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Max Points</th>
<th>Your Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research Question</strong></td>
<td>• Research question is clearly stated and answered using support from experimental and group data.</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
| **Background**    | • Explores the motivation (the why) for answering the research question.  
• Provides connections to other topics, concepts in physics, and real-world connections. | 4          |            |
| **Explanation**   | • Explains relevant physics concepts (equations, variables, etc.) that are used to investigate the research question. | 3          |            |
### Gallery Walk Hand out

<table>
<thead>
<tr>
<th>Presentation 1</th>
<th>Presentation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Members Names:</td>
<td>Group Members Names:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What procedure/process did this group use to collect their data? Your main results with calculations.</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>What were the main conclusions/results of this group?</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>What errors did they site? Based on the group’s assessment, do you think their results are accurate?</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>What physics explanation did they provide as an answer to the question in the lab?</th>
<th></th>
</tr>
</thead>
</table>
Re-take Assessment for Module #5: Forces

Name: ____________________________  Unit 4: Forces
November 14, 2018  Forces EXAM

Forces RETAKE

F1

1. State Newton’s 3 Laws [1]
   a. 1st Law:

   b. 2nd Law:

   c. 3rd Law:

2. Which object has the least inertia? [1]
   a. A 0.010 kg bullet traveling at 90 m/s
   b. A 30 kg child traveling at 10 m/s on her bike.
   c. A 490 kg elephant walking with a speed of 1.0 m/s.
   d. A 1500 kg car at rest in a parking lot.

3. Which situation represents equilibrium? [1]
   a. A satellite circling the earth.
   b. An elephant moving upward at constant speed in an elevator.
   c. A roller coaster ride turning a corner in a cart on the track
   d. A track runner accelerating from rest through a 100 yard dash

4. The mass of a tennis ball is closest to [1]
   a. $7.0 \times 10^{-1}$ kg
   b. $7.0 \times 10^2$ kg
   c. $7.0 \times 10^6$ kg

5. A 750 N bus driver applies 10 N of force to a 0.22 N peddle to cause an acceleration. The force of the driver’s foot on the peddle is equal to [1]:
   a. 750 N
   b. 0.22 N
   c. 10 N
   d. 850 N

6. On a small planet, an alien lifts a 65 kg miniature spaceship 0.430 meters above the surface of the planet at constant velocity by applying a force of 155 N. What is the magnitude of the gravitational field on the surface of the planet? [1]
1. An elevator is moving upward at increasing speed. A 850 N student is standing on a bathroom scale in the elevator car. The reading on the scale is closest to: [1]
   a. 9.8 N  
   b. 850 N  
   c. 800 N  
   d. 900 N

2. Two forces act concurrently on an object. Their resultant force has the greatest magnitude when the angle between the forces is [1]
   a. 0°  
   b. 90°  
   c. 30°  
   d. 180°

3. A constant eastward horizontal force of 70. newtons is applied to a 20.-kilogram crate moving toward the east on a level floor. If the frictional force on the crate has a magnitude of 10. newtons, what is the magnitude of the crate’s acceleration?
   a. 0.50 m/s²  
   b. 3.0 m/s²  
   c. 5.0 m/s²  
   d. 4.0 m/s²

4. An 8.00 kg object is accelerated at 5.0 m/s² by an unbalanced force. What is the magnitude of this force? [1]

5. A 35-Newton force is applied to a 7.0-kg box causing it to accelerate at a rate of 2.5 m/s² across a horizontal floor. Draw a free body diagram of the box and determine the net force acting on it. [2]

6. A child applies a horizontal force to an 80.0 kg sled on snow of negligible friction, causing the sled to accelerate uniformly at 1.30 m/s² to the right.
   a. Calculate the magnitude of the force applied to the sled by the child [2]
   b. Draw a Free Body Diagram for the sled. Label all forces and calculate the magnitude of each. [2]
F2b

1. A shoe is at rest on an inclined ramp. As the angle of the incline is decreased, the force of static friction: [1]
   a. Increases.
   b. Decreases.
   c. Remains the same.
   d. Equals the kinetic friction.

2. A 55.0 kg box starting at rest is being pulled across the floor by a rope. A force of 83.0 N is applied through the rope at an angle of 29° above the horizontal. The kinetic force of friction is 21.0 N.
   a. What is the net force acting on the block? [2]

   b. What is the final velocity of the box after it has traveled a distance of 3.0 meters? [1]

3. A 12.00 N block accelerates from rest down a frictionless ramp inclined at 35° to the horizon.
   a. Draw a free body diagram for the block and determine the net force. Label all forces. [2]

   b. What is the magnitude of the block’s acceleration? [2]
1. A car’s performance is tested on various horizontal surfaces. The brakes are applied, causing the rubber tires of the car to slide along the road without rolling. The tires encounter the least force of friction to stop the car on[1]
   a. Dry concrete
   b. Dry asphalt
   c. Wet concrete
   d. Wet asphalt

2. A 22.0-newton rubber block slides across a horizontal concrete sidewalk at constant velocity. What is the magnitude of the force of kinetic friction between the block and the floor? [2]

3. As shown in the diagram below, an open box and its contents have a combined mass of 5.0 kilograms. A horizontal force of 15 newtons is required to push the box at a constant speed of 1.5 meters per second across a level surface. Calculate the coefficient of the force of friction acting on the moving block. [2]

4. A 50.-Newton force is applied to a 6.0-kg box causing it to accelerate at a rate of 2.0 m/s\(^2\) across a horizontal floor. What is the coefficient of friction between the box and the floor? [2]
Z1

1. A 25.0 kg box is pushed from rest with a force of 150 N to the right and has a kinetic frictional force of 65 N. What is the velocity of the block after 4.00 seconds? [2]

2. A football is propelled with an initial velocity of 52.0 meters per second at 37° above the horizontal.
   a. What is the total time the football is in the air? [2]

   b. What is the maximum vertical height reached by the football? [2]

3. An object is kicked off a 115 meter high cliff with an initial horizontal velocity of 13.2 m/s.
   a. What is the horizontal component of the velocity just before it hits the ground? [1]

   b. Calculate the horizontal distance traveled by the projectile. (Ignore Air Resistance) [2]
Example of Gradebook Snapshot for Module #5: Forces

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades are listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
<thead>
<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Forces:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>F1a</th>
<th>F1b</th>
<th>F2a1</th>
<th>F2a2</th>
<th>F2b1</th>
<th>F2b2</th>
<th>F3a</th>
<th>F3b</th>
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<td>4</td>
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</tr>
<tr>
<td>student A</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Student B</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Student C</td>
<td>2.0</td>
<td>3.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>3.5</td>
<td>2.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Module Kit #6: Electrostatics

<table>
<thead>
<tr>
<th>Title</th>
<th>Unit 6: Electrostatics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source/website</td>
<td>Created by E. Carbone 10/15/19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NYS Physics Standard</th>
<th>Key Ideas:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS2.B: Types of Interactions: Newton’s law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.</td>
<td></td>
</tr>
<tr>
<td>PS2.B: Types of Interactions: Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.</td>
<td></td>
</tr>
<tr>
<td>PS3.C: Relationship Between Energy and Forces • When two objects interacting through a field change relative position, the energy stored in the field is changed.</td>
<td></td>
</tr>
</tbody>
</table>

| Supplies | • Electrostatics Standards one-pager  
|          | • List of standards paired with “I can” statements and standard codes  
|          | • Unit Test: Electrostatics (bubble sheet, test booklet, answer key, questions sorted by standard)  
|          | • Electrostatics Test Retake: test booklet with questions sorted by standard, answer key  
|          | • Sample student feedback score sheet  
|          | • Student re-assessment reflection guide |

| Summary | This unit is more of a conceptual units, students will need to visualize forces and Fields on a molecular level. The challenge of this unit is giving students’ models and visuals of the forces and Fields of these charges and magnets on a macroscopic level that students can see an experiment with. This unit serves as an excellent launch into the next unit on electricity. In electrostatics students learn about charges and see the effects that different charges can have on each other. This will help students to better understand the concept of moving charges in order to create electricity. |

|         | As part of the activities for this unit, students will do a number of online simulations to better visualize the forces and Fields of charges. The simulations do a nice job of using arrows of different lengths to represent forces of different magnitudes. They also form force fields and magnetic fields around charges and do an excellent job of showing how multiple charges in the same space will interact and how that will alter the force fields. Students will play a game called force field hockey as a experiment with the forces a various charges on an electron. Students will also experiments with magnets and compasses, determining how a magnet is affected by Earth's magnetic poles. Soon as will also experiment with various types of charging using a pith ball demo and some pieces of Scotch tape rub with various materials. Students will also get the opportunity to experiment with a Van de graaff generator and show the power that charge build-up can have on other materials. This unit will end with students doing a project on various types of charging with electrosopes as well as on magnetic fields with iron filings. |
The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standards: Electrostatics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard:</strong></td>
</tr>
<tr>
<td>ES1</td>
</tr>
<tr>
<td>ES2</td>
</tr>
<tr>
<td>ES3</td>
</tr>
<tr>
<td>ES4</td>
</tr>
</tbody>
</table>

**Possible Common Misconceptions:**

Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery of electrostatics that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from *New York Science Teacher: Physics Misconceptions*, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.

| ES1  | Conservation of Charge | - Positively charged objects have gained protons, rather than being deficient in electrons.  
- Electrons which are lost by an object are really lost (no conservation of charge).  
- All atoms are charged. |
| ES2  | Coulomb's Law | - A charged object can only attract other charged objects.  
- The electrostatic force between two charged objects is independent of the distance between them.  
- Gravitational forces are stronger than electrostatic forces.  
- Larger magnets are stronger than smaller magnets. |
| ES3  | Electric & Magnetic Fields | - A charged object can only attract other charged objects.  
- Batteries have electricity inside them.  
- The magnetic and geographic poles of the earth are located at the same place.  
- The magnetic pole of the Earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole. |
| ES4  | Magnetism | - All metals are attracted to a magnet.  
- All silver colored items are attracted to a magnet.  
- All magnets are made of iron.  
- Larger magnets are stronger than smaller magnets.  
- The magnetic and geographic poles of the earth are located at the same place.  
- The magnetic pole of the Earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole. |
Appendix of Supplemental Materials for Module Kit #6

Test for Module #6: Electrostatics

Name: ____________________________  Period: ______

Unit 8 Quest: Electrostatics

Directions:

* Mark multiple choice questions on the separate answer sheet. Only answers marked on the answer sheet will be scored.
* Write your responses to extended-response questions on the separate answer sheet. Only answers marked on the answer sheet will be scored. Use complete sentences and proper grammar when appropriate.
* Show ALL work for calculations in FSA format.
* You may use the References Tables for Physical Setting / Physics as well as a pen/pencil, ruler, protractor, and scientific calculator on this exam.
Base your answer to questions 1-2 on the information and diagram below.

Two small metallic spheres, A and B, are separated by a distance of $4.0 \times 10^{-1}$ meter, as shown. The charge on each sphere is $+1.0 \times 10^{-6}$ coulomb. Point P is located near the spheres.

1. What is the magnitude of the electrostatic force between the two charged spheres?
   - 1. $2.2 \times 10^{-5}$ N
   - 2. $2.2 \times 10^{-4}$ N
   - 3. $5.6 \times 10^{-5}$ N
   - 4. $5.6 \times 10^{-4}$ N

2. If the distance between the two spheres is reduced to $2.0 \times 10^{-3}$ m, the magnitude of the electric force between the spheres will be
   - 1. one-fourth as great
   - 2. one-half as great
   - 3. two times as great
   - 4. four times as great

3. According to the triboelectric series shown to the right, if wool were charged by friction with steel
   - 1. Negative charges would transfer from the wool to the steel
   - 2. Positive charges would transfer from the wool to the steel
   - 3. Negative charges would transfer from the steel to the wool
   - 4. Positive charges would transfer from the steel to the wool

4. A metal sphere having an excess of +5 elementary charges has a net electric charge of
   - 1. $1.6 \times 10^{19}$ C
   - 2. $5.0 \times 10^{19}$ C
   - 3. $8.0 \times 10^{19}$ C
   - 4. $3.2 \times 10^{19}$ C

The diagram below represents two electrically charged identical-sized metal spheres, A and B.

5. If the spheres are brought into contact, which sphere will have a net gain of electrons?
   - 1. A, only
   - 2. B, only
   - 3. both A and B
   - 4. Neither A nor B

6. What is the approximate electrostatic force between two protons separated by a distance of $2.0 \times 10^{-4}$ meter?
   - 1. $5.8 \times 10^{-17}$ N and repulsive
   - 2. $5.8 \times 10^{-17}$ N and attractive
   - 3. $1.2 \times 10^{-22}$ N and repulsive
   - 4. $1.2 \times 10^{-22}$ N and attractive

7. An atom of magnesium could have many possible oxidation states where the element has gained or lost electrons. Which of these charges is NOT possible:
   - 1. $+2.4 \times 10^{-19}$ C
   - 2. $+3.2 \times 10^{-19}$ C
   - 3. $+8.0 \times 10^{-19}$ C
   - 4. $+9.6 \times 10^{-19}$ C

8. What is the strength of an electric field that produces a force of $1.5 \times 10^6$ N on an electron?
   - 1. $2.6 \times 10^{-23}$ N/C
   - 2. $9.4 \times 10^{-23}$ N/C
   - 3. $2.6 \times 10^{12}$ N/C
   - 4. $9.4 \times 10^{12}$ N/C

9. Which procedure will double the force between two point charges?
   - 1. doubling the distance between the charges
   - 2. doubling the magnitude of one charge
   - 3. halving the distance between the charges
   - 4. halving the magnitude of one charge
The diagram below represents the electric field in the region of two small charged spheres, A and B.

10. What is the sign of the net charge on A and B?
   1. A is positive and B is positive.
   2. A is positive and B is negative.
   3. A is negative and B is negative.
   4. A is negative and B is positive.

In the diagram below, point P is located in the electric field between two oppositely charged parallel plates.

11. Compared to the magnitude and direction of the electrostatic force on an electron placed at point P, the electrostatic force on a proton placed at point P has
   1. the same magnitude and the same direction
   2. the same magnitude, but the opposite direction
   3. a greater magnitude, but the same direction
   4. a greater magnitude and the opposite direction

The diagram shows the lines of magnetic force between two north magnetic poles.

12. At which point is the magnetic field strength greatest?
   1. A
   2. B
   3. C
   4. D

13. What is the net electrical charge on a magnesium ion that is formed when a neutral magnesium atom loses two electrons?
   1. $-3.2 \times 10^{-19}$ C
   2. $-1.6 \times 10^{-19}$ C
   3. $+1.6 \times 10^{-19}$ C
   4. $+3.2 \times 10^{-19}$ C

14. Two charges that are 2 meters apart repel each other with a force of $2 \times 10^5$ newton. If the distance between the charges is decreased to 1 meter, the force of repulsion will be
   1. $1 \times 10^6$ N
   2. $5 \times 10^6$ N
   3. $8 \times 10^6$ N
   4. $4 \times 10^6$ N

15. What is the magnitude of the electric force acting on an electron located in an electric field with an intensity of $5.0 \times 10^6$ newtons per coulomb?
   1. $3.2 \times 10^{-23}$ N
   2. $8.0 \times 10^{-16}$ N
   3. $5.0 \times 10^2$ N
   4. $3.2 \times 10^{22}$ N
16. When a neutral metal sphere is charged by contact with a positively charged glass rod, the sphere [1]

1. loses electrons
2. loses protons
3. gains electrons
4. gains protons

The diagram below shows two identical metal spheres, A and B, separated by distance d. Each sphere has mass m and possesses charge q.

17. Which diagram best represents the electrostatic force $F_e$ and the gravitational force $F_g$ acting on sphere B due to sphere A?

1. 
2. 
3. 
4. 

A positive test charge is placed between an electron, e, and a proton, p, as shown in the diagram.

18. When the test charge is released, it will move toward

1. A
2. B
3. C
4. D

19. Which graph best represents the electrostatic force between an alpha particle with a charge of +2 elementary charges and a positively charged nucleus as a function of their distance of separation?
20. A negatively charged plastic comb is brought close to, but does not touch, a small piece of paper. If the comb and the paper are attracted to each other, the charge on the paper

1. may be negative or neutral
2. may be positive or neutral
3. must be negative
4. must be positive

21. Which diagram correctly shows a magnetic configuration?

1. 

2. 

3. 

4. 

22. Which diagram below best represents the position of the needle of the compass as it responds to the magnetic field of the bar magnet?

The diagram below shows a compass placed near the North Pole, N, of a bar magnet.

**Constructed Response:** For calculations, show all work in FSA format and show all work. Use complete sentences and proper grammar where appropriate.
Base your answer to the questions 23-25 on the information below and your knowledge of physics.

Two charged spheres are separated by a distance of $7.4 \times 10^{-2}$ m. One sphere has a charge of $+4.8 \times 10^6$ C and the other sphere a charge of $-8.0 \times 10^6$ C.

23. A. Identify the charge of the sphere that has an excess of electrons. [1] ______________________

   B. How many excess electrons are on the sphere you answered in part a? [1]

24. Determine the magnitude and direction (attractive or repulsive) of the electrostatic force between the two spheres [Show all work, including the equation and substitution with units.] [2]

25. If the two spheres are allowed to contact, determine the charge afterward on each sphere. [2]

Base your answer to questions 25-26 on the information and diagram below and on your knowledge of physics.

Two conducting parallel plates $5.0 \times 10^{-3}$ meter apart are charged with a 12-volt potential difference. An electron is located midway between the plates. The magnitude of the electrostatic force on the electron is $3.8 \times 10^{-16}$ Newton.

26. What direction is the electrostatic force that the electric field exerts on the electron? [1] ______________________

27. Calculate the magnitude of the electric field strength between the plates. [2]
## TEST SCORE BREAKDOWN BY STANDARD

**Student: Example A**

**Assessment: Unit 6 Electrostatics**

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Correct Answer</th>
<th>Student Answer</th>
<th>Correct Points Earned</th>
<th>Out Of</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>ES1 Conservation of Change: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>ES1 Conservation of Change: I can determine how charge will move in a system and the way an object becomes charged.</td>
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</tbody>
</table>
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Standard Questions linked to Standard

ES1: Conservation of Charge-
I can determine how charge will move in a system and the way an object becomes charged.

4. A metal sphere having an excess of +5 elementary charges has a net electric charge of

1. \( 1.6 \times 10^{-19} \text{ C} \)  
2. \( 5.0 \times 10^0 \text{ C} \)  
3. \( 8.0 \times 10^{-19} \text{ C} \)  
4. \( 3.2 \times 10^1 \text{ C} \)

The student needs to recognize the amount of charge on each elementary charge is a multiple of \( 1.6 \times 10^{-19} \). If an object has an excess of 5 charges, this object will have a charge of 5 times the value of an elementary particle.

ES2: Coulomb’s Law
I can determine the electrostatic force between objects.

1. 2, 6, 9, 14, 17, 19, 24

---

**Standard**

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Correct Answer</th>
<th>Student Answer</th>
<th>Correct Points Earned</th>
<th>Out Of</th>
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<tbody>
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<td>12</td>
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</table>

Your Score: 24 out of 31

Percent Score: 77.42%

---

A Correct Answer of "X" indicates that any answer was acceptable. EC Indicates the question was for Extra Credit

<table>
<thead>
<tr>
<th>Standard</th>
<th>Points</th>
<th>Percent</th>
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<tr>
<td>ES1 Conservation of Change: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>8 / 11</td>
<td>72.73%</td>
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<td>ES2 Coulomb’s Law: I can determine the electrostatic force between objects.</td>
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<td>88.89%</td>
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<td>ES3 Electric &amp; Magnetic Fields: I can describe the electric field due to a charge or magnet</td>
<td>3 / 6</td>
<td>50%</td>
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<tr>
<td>ES4 Magnetism: I can describe the source of a magnetic field.</td>
<td>5 / 5</td>
<td>100%</td>
</tr>
</tbody>
</table>

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A student needs to recognize first that these two charged spheres will have an electrostatic force between them. This force is related to the distance the spheres are apart (radius) as well as the amount of charge on each sphere. Students will need to use that information, in conjunction with their knowledge of the electric force constant, \( k \), to solve for Coulomb’s Law.

### Question 8

What is the strength of an electric field that produces a force of \( 1.5 \times 10^6 \) N on an electron?

- 1. \( 2.6 \times 10^{-5} \) N/C
- 2. \( 9.4 \times 10^{-5} \) N/C
- 3. \( 2.6 \times 10^{12} \) N/C
- 4. \( 9.4 \times 10^{12} \) N/C

The strength of a field is related to the amount of force on each unit of charge, or coulomb. Students will need to solve this formula, while also recognizing the charge of a single electron in coulombs, to find the electric field strength represented in question 8.
I can describe the source of a magnetic or electric field.

The diagram below represents the electric field in the region of two small charged spheres, A and B.

10. What is the sign of the net charge on A and B?
   1. A is positive and B is positive.
   2. A is positive and B is negative.
   3. A is negative and B is negative.
   4. A is negative and B is positive.

A student will need to know the conventional directions for the electric field to solve this problem. Students can recognize that since both fields are moving in the same directions around the two particles and also appear to repel the field from the other particle that the charges have the same value. Students need to know that when it comes to electric fields, the field lines conventionally point to the negative charges.
Independent Student Reflection Document for Module #6: Electrostatics

The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Nearpod Reflection Document:

ELECTROSTATICS REFLECTIONS
Which standard was most difficult for you, based on your assessment score?

- A. ES1
- B. ES2
- C. ES3
- D. ES4

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific.

Ready? Enter your answer here.

If you plan to retake a second standard, which one will it be?

- A. ES1
- B. ES2
- C. ES3
- D. ES4
What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

A. Utilize Castle Learning questions for this standard  
B. Meet with Mrs. Carbone to discuss questions  
C. Read topic and answer sample questions on ClassroomPhysics.com  
D. Create flashcards to memorize terms and units that caused confusion  
E. Watch videos on this topic at Khan Academy to deepen understanding  
F. Go through notes  
G. Other

What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of electrostatics and the four standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project require students to apply their knowledge of the standards, as well as their own ingenuity, to the creation and evaluation of their own musical instrument.

For this particular project, students will experiment with both charging and electric and magnetic fields. This project is more guided than some of the other projects, as this project lends itself to having students follow and activity. In the first section of this project, students will be able to explore three different types of charging using an electroscope. They will be able to visually see and we'll need to model via a drawing charging by polarization, conduction, and induction. Students will need to both produce a drawing model other observations as well as right conclusions. Part two of the project requires students to explore magnetic and electric fields. They will be using magnets, a compass, and iron filings. These materials allow students to actually see magnetic fields form. Soon as will follow the guide to both model magnetic field lines as well as make inclusions about their implications, particularly when it comes to the magnetic poles of the Earth.

Completing this project requires students to address each of the four standards associated with electrostatics. These standards will be addressed not only by how they perform the experiments but also by how they model what is happening. The depth of learning is significantly increased when students can apply that learning directly to an application.

**Electrostatics Application Project:**

**Electroscope Challenge – Types of Charging**

**Objective:** To determine the effects of positive and negative charges while charging an object with different methods.

**Procedure:** For each of the different methods of charging, show:
- The position of the rod in the electroscope.
- A microscopic view of charges on the electroscope.

**Type 1 - Polarization:**
- Show the effects of bringing a *negative* charge to the top of the electroscope without touching. (Make a negative by rubbing the vinyl rod with the wool cloth).
b. What causes the arm of the electroscope to move?

**Type 2 – Conduction:**

- a) Complete the sequence below by charging a *negative* rod and touching the rod to the top of the electroscope (you may need to do this a few times to see the effect). Then, ground the electroscope by touching the top with your finger.

- b) What happens to the electrons in the rod when it touches the top of the electroscope?

- c) What happens to the electrons on the electroscope when you touch it with your finger?

- d) Why does the effect in question c not happen when you are touching the rod?
Type 3 – Induction:

a) Complete the sequence below by charging a negative rod and then bringing it near (but not touching) and then grounding before taking the rod away.

(Neutral)  (Near)  (Ground)  (Away)  (Ground)

b) Describe what happens to the electrons when your finger touches the top of the electroscope and the charged rod is still near?

c) During induction, why is it important to remove your finger first and then the charged object?
Magnetic Fields Challenge Activity

**Objective:** To describe how a compass reacts with a magnetic field and to analyze the magnetic field produced by various objects.

**Part A:**
Using 1 bar magnet at your lab station, visualize the magnetic field around that magnet by spreading iron filings above the magnet on plastic sheet. Draw at least 4 Magnetic field (B-field) lines in the correct direction.

1. a) Where are field lines closest? ________________________
   b) What does this imply? ________________________________

2. Do the magnetic field lines you produced ever cross each other?

3. Place your compass somewhere around the bar magnet. Sketch the compass on the diagram above and explain the direction observed.

**Procedure Part B:**
Hold 2 bar magnets near each other, so that the North & South poles are in close proximity. Repeating the procedure above, draw at least 4 Magnetic field lines between the poles in the correct direction.

**Procedure Part C:**
Hold 2 bar magnets near each other, so that the TWO South poles are in close proximity. Repeating the procedure above, draw **at least 4** Magnetic field lines between the poles in the **correct** direction.

**Procedure Part D:**
Use a small compass to “map” the field surrounding a bar magnet. In each of the circles, draw an arrow to represent the direction the North pole of a magnetic compass.

4. How is the direction of the compass related to the magnetic field lines produced in part B?

5. Which direction does the compass always point?
Re-take Assessment for Module 6: Electrostatics

Unit 8 Electrostatics Test RETAKE

Name: ____________________________  Period: ______

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tr>
<td>ES1</td>
<td>/8</td>
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<tr>
<td>ES2</td>
<td>/3</td>
<td></td>
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<tr>
<td>ES3</td>
<td>/10</td>
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<td>/10</td>
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<td>Total</td>
<td>/33</td>
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</tbody>
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**ES1**

1. A metal sphere having an excess of +3 elementary charges has a net electric charge of

   1. \(1.6 \times 10^{-19} \text{ C}\)
   2. \(4.8 \times 10^{-19} \text{ C}\)
   3. \(8.0 \times 10^{-19} \text{ C}\)
   4. \(3.2 \times 10^{-19} \text{ C}\)

   Two charged spheres are separated by a distance of 7.4 \(x 10^2 \text{ m}\). One sphere has a charge of \(-5.2 \times 10^6 \text{ C}\) and the other sphere a charge of \(-4.8 \times 10^6 \text{ C}\).

2. If the spheres shown above are brought into contact, which sphere will have a net loss of electrons?

   1. A, only
   2. B, only
   3. both A and B
   4. Neither A nor B

3. An atom of nitrogen could have many possible oxidation states where the element has gained or lost electrons. Which of these charges is NOT possible:

   1. \(+3.2 \times 10^{-19} \text{ C}\)
   2. \(-8.0 \times 10^{-19} \text{ C}\)
   3. \(+5.0 \times 10^{-19} \text{ C}\)
   4. \(+9.6 \times 10^{-19} \text{ C}\)

4. What is the net electrical charge on a chlorine ion that is formed when a neutral chlorine atom gains one electron?

   1. \(-3.2 \times 10^{-19} \text{ C}\)
   2. \(+1.6 \times 10^{-19} \text{ C}\)
   3. \(-1.6 \times 10^{-19} \text{ C}\)
   4. \(+3.2 \times 10^{-19} \text{ C}\)

B. How many excess electrons are on the sphere you answered in part a? [1]

C. If the two spheres are allowed to contact, determine the charge afterward on each sphere. [2]
ES2

6. According to the triboelectric series shown to the right, if wool were charged by friction with nylon

1. Negative charges would transfer from the wool to the nylon
2. Positive charges would transfer from the wool to the nylon
3. Negative charges would transfer from the nylon to the wool
4. Positive charges would transfer from the nylon to the wool

7. When a neutral metal sphere is charged by contact with a negatively charged aluminum rod, the sphere [1]

1. loses electrons
2. loses protons
3. gains electrons
4. gains protons

8. A positively charged aluminum rod is brought close to, but does not touch, a small piece of paper. If the rod and the paper are repelled from each other, the charge on the paper

1. may be negative or neutral
2. may be positive or neutral
3. must be negative
4. must be positive

5. A dry plastic rod is rubbed with wool cloth and then held near a thin stream of water from a faucet. The path of the stream of water is changed, as represented in the diagram below.

Which force causes the path of the stream of water to change due to the plastic rod?

1. Nuclear
2. Electrostatic
3. Magnetic
4. gravitational
9. What is the approximate electrostatic force between an electron and a proton separated by a distance of $2.0 \times 10^{-8}$ meter?

1. $5.8 \times 10^{-17}$ N and repulsive  
2. $5.8 \times 10^{-17}$ N and attractive  
3. $1.2 \times 10^{-22}$ N and repulsive  
4. $1.2 \times 10^{-22}$ N and attractive

10. Which procedure will halve the force between two point charges?

1. doubling the distance between the charges  
2. doubling the magnitude of one charge  
3. halving the distance between the charges  
4. halving the magnitude of one charge

11. Compared to the magnitude and direction of the electrostatic force on an electron placed at point $P$, the electrostatic force on a proton placed at point $P$ has

1. the same magnitude and the same direction  
2. the same magnitude, but the opposite direction  
3. a greater magnitude, but the same direction  
4. a greater magnitude and the opposite direction

12. Two charges that are 2 meters apart repel each other with a force of $4 \times 10^{-5}$ newton. If the distance between the charges is increased to 4 meters, the force of repulsion will be

1. $1 \times 10^{-5}$ N  
2. $16 \times 10^{-8}$ N  
3. $8 \times 10^{-5}$ N  
4. $4 \times 10^{-5}$ N

13. The diagram below shows two identical metal spheres, $A$ and $B$, separated by distance $d$. Each sphere has mass $m$ and possesses charge $q$.

In the diagram below, point $P$ is located in the electric field between two oppositely charged parallel plates.

14. Which graph best represents the relationship between electric field intensity and the distance from a point charge?
15. What is the magnitude of the electrostatic force between the two charged spheres?

- 1. $5.6 \times 10^{-2}$ N
- 2. $5.6 \times 10^{6}$ N
- 3. $1.4 \times 10^{-2}$ N
- 4. $1.4 \times 10^{4}$ N

16. If the distance between the two spheres is increased to $16.0 \times 10^{-1}$ m, the magnitude of the electric force between the spheres will be

- 1. one-fourth as great
- 2. two times as great
- 3. one-half as great
- 4. four times as great

17. Two charged spheres are separated by a distance of $7.4 \times 10^{-1}$ m. One sphere has a charge of $-5.2 \times 10^{-6}$ C and the other sphere a charge of $-4.8 \times 10^{6}$ C. Determine the magnitude and direction (attractive or repulsive) of the electrostatic force between the two spheres [Show all work, including the equation and substitution with units.] [2]
18. Which diagram represents the electric field between two oppositely charged conducting spheres?

![Diagram of electric fields between charged spheres]

1. 
2. 
3. 
4. 

The diagram shows the lines of magnetic force between two north magnetic poles.

19. At which point is the magnetic field strength greatest?

1. A 
2. B 
3. C 
4. D

20. What is the magnitude of the electric force acting on a proton located in an electric field with an intensity of $8.0 \times 10^9$ newtons per coulomb?

21. What is the strength of an electric field that produces a force of $1.5 \times 10^{-8}$ N on a proton?

1. $2.6 \times 10^{-2}$ N/C 
2. $9.4 \times 10^{-3}$ N/C 
3. $2.6 \times 10^{-7}$ N/C 
4. $9.4 \times 10^{-6}$ N/C

22. In the diagram below, P is a point near a negatively charged sphere.

Which vector best represents the direction of the electric field at point P?

1. 
2. 
3. 
4. 

23. Which diagram correctly shows a magnetic configuration?
The diagram below shows a compass placed near the North Pole, N, of a bar magnet.

24. Which diagram below best represents the position of the needle of the compass as it responds to the magnetic field of the bar magnet?

1.  
2.  
3.  
4.  

Two conducting parallel plates 8.0 × 10⁻³ meter apart are charged with a 9-volt potential difference. An electron is located midway between the plates. The magnitude of the electrostatic force on the electron is 7.2 × 10⁻¹⁰ Newton.

25. What direction is the electrostatic force that the electric field exerts on the electron? [1]

26. On the diagram, draw at least three field lines to represent the direction of the electric field in the space between the charged plates [1]

27. Calculate the magnitude of the electric field strength between the plates. [2]
Example of Gradebook Snapshot for Module #6: Electrostatics

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades a listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

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<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
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<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook Electrostatics:

<table>
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<tr>
<th>Assignment</th>
<th>ES1a</th>
<th>ES1b</th>
<th>ES2a</th>
<th>ES2b</th>
<th>ES3a</th>
<th>ES3b</th>
<th>ES4a</th>
<th>ES4b</th>
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<tr>
<td>TOTAL POINTS</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>student A</td>
<td>3.5</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
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<tr>
<td>Student B</td>
<td>3.0</td>
<td>4.0</td>
<td>2.0</td>
<td>3.5</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Student C</td>
<td>2.0</td>
<td>3.0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>3.5</td>
<td>2.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>
## Module Kit #7: Electricity

<table>
<thead>
<tr>
<th>Title:</th>
<th>Unit 7: Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source/website:</td>
<td>Created by E. Carbone 11/12/19</td>
</tr>
<tr>
<td>NYS Physics Standard:</td>
<td>Key Ideas:</td>
</tr>
<tr>
<td></td>
<td>PS3.B: Conservation of Energy and Energy Transfer: Electrical power and energy can be determined for electric circuits.</td>
</tr>
<tr>
<td></td>
<td>PS3.D: Energy in Chemical Processes: Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy.</td>
</tr>
<tr>
<td>Supplies</td>
<td>• Electricity Standards one-pager</td>
</tr>
<tr>
<td></td>
<td>• List of standards paired with “I can” statements and standard codes</td>
</tr>
<tr>
<td></td>
<td>• Unit Test: Electricity (bubble sheet, test booklet, answer key, questions sorted by standard)</td>
</tr>
<tr>
<td></td>
<td>• Electricity Test Retake: test booklet with questions sorted by standard, answer key</td>
</tr>
<tr>
<td></td>
<td>• Sample student feedback score sheet</td>
</tr>
<tr>
<td></td>
<td>• Student re-assessment reflection guide</td>
</tr>
<tr>
<td>Summary:</td>
<td>This unit on electricity will be a great introduction to key components involved in circuits, namely batteries and voltage supplies, resistors, wires, etc. After learning vocabulary and the basics of how electricity moves through a circuit, students will explore the differences between parallel and series circuits, taking into consideration current, voltage, and resistance. The unit will conclude with students studying work and power involved in an electric circuit and the meanings of those. Much of this unit will be done on snap circuits, circuits that ‘snap’ together in a similar way that Legos do. This allows students to quickly build all different types of circuits, including series, parallel, and complex circuits. Students will then be able to measure various components using an ammeter and voltmeter and will learn how to connect these into their circuit. In addition to the snap circuits, students will explore resistance and resistivity in two labs, one of which using conductive Play-Doh and power supplies and the other using various materials that can be used to build resistors and compare conductivity between these. Finally, students will look at power and work generated by components used every day in their houses. Students will put together an estimate for their family’s monthly RG&amp;E bill based on components running in their house, the power of these components, how often they run on average, and the average cost of energy in the area.</td>
</tr>
<tr>
<td></td>
<td>This unit directly relates to the real world by allowing students to have simple hands-on practice with circuits, learning the dangers as well as the basics to circuitry. Additionally students will have a knowledge of how to use ammeters and voltmeters, common skill required to own a home. Finally, studying circuits will hopefully spark some interest and students in the electrical field. If nothing else, students will be aware of the amount of energy is being used in their own home and how to conserve it through limiting general usage as well as purchasing components that are energy sufficient.</td>
</tr>
</tbody>
</table>
The following standards are a list of what will be explored in this unit. Each represent a category that will be used in the standards based grading assessment cycle. Students will receive this list of standards at the beginning of the unit and will utilize these as a guide to assessing their individual understanding and success.

<table>
<thead>
<tr>
<th>Standard:</th>
<th>Topic:</th>
<th>Knowledge Check:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL1</td>
<td>Electric Potential</td>
<td>I can determine the energy used in moving a charge between points.</td>
</tr>
<tr>
<td>EL2</td>
<td>Resistance</td>
<td>I can determine the resistance of a wire based on its characteristics.</td>
</tr>
<tr>
<td>EL3</td>
<td>Ohm’s Law and Current</td>
<td>I can relate resistance, voltage, and current.</td>
</tr>
<tr>
<td>EL4</td>
<td>Series Circuits</td>
<td>I can construct and analyze a circuit with one path.</td>
</tr>
<tr>
<td>EL5</td>
<td>Parallel Circuits</td>
<td>I can construct and analyze a circuit with multiple paths.</td>
</tr>
<tr>
<td>EL6</td>
<td>Electrical Energy And Power</td>
<td>I can determine the energy expended or power used in an electrical system.</td>
</tr>
</tbody>
</table>

Possible Misconceptions:
Taking this assessment will allow students to recognize areas of their greatest misconceptions and give them an opportunity to demonstrate re-mastery of mechanical waves that they may have missed prior to the test. Some of the more common misconceptions for this unit, based on data from New York Science Teacher: Physics Misconceptions, are listed below. The misconception list was sorted as they applied to each standard. The misconceptions, whether they are from movies or prior misunderstandings, will be specifically addressed in the class.
materials and the assessment will evaluate whether or not students have corrected these and replaced them with a deep conceptual understanding of the content.

|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| **Standard:** | **Topic:** | **EL1** Electric Potential  
- Batteries store charge  
- Batteries want to produce a particular current  
- When an electrochemical cell no longer works, it is out of charge and must be recharged before it can be used again.  
- An electrochemical cell can be a source of charge in a circuit. The charge that flows through the circuit originates in the cell.  
- Batteries & generators create electricity  
- Electricity leaves one battery plate, then returns to the other.  

**EL2** Resistance  
- High resistance bulbs are brighter than low resistance ones  
- Thick wires have a lower resistance because the charges have more space  
- Electrons flow at nearly the speed of light  
- Materials are either very good conductors or very good insulators.  

**EL3** Ohm’s Law and Current  
- The current takes the easiest route  
- Charges slow down as they go through a thin piece of wire  
- Current wants to flow and circuits try and resist or split this current.  
- Charges move very quickly through empty wires  
- When a circuit is completed, the current (electrons or particles carrying charge) pours out of the battery and round the circuit  
- When the current stops flowing the electrons all go back into the battery.  

**EL4** Series Circuits  
- Charge becomes used up as it flows through a circuit.  
- The amount of charge that exits a light bulb is less than the amount that enters the light bulb.  
- Charge flows through circuits at very high speeds. This explains why the light bulb turns on immediately after the wall switch is flipped.  
- Charge is shared between the various parts of the circuit.  


| EL5   | Parallel Circuits | - Voltage is shared between the various parts of the circuit  
|       |                  | - Charge flows through circuits at very high speeds. This explains why the light bulb turns on immediately after the wall switch is flipped.  
|       |                  | - Charge becomes used up as it flows through a circuit.  
|       |                  | - The amount of charge that exits a light bulb is less than the amount that enters the light bulb.  |
| EL6   | Electrical Energy And Power | - The local electrical utility company supplies millions and millions of electrons to our homes every day. |
Appendix of Supplemental Materials for Module Kit #7

Test for Module #7: Electricity

Name: ____________________________  Period: ______

Exam: Electricity & Current

Directions:

* Mark multiple choice questions on the separate answer sheet. Only answers marked on the
  answer sheet will be scored.
* Write your responses to extended-response questions on the separate answer sheet. Only
  answers marked on the answer sheet will be scored. Use complete sentences and proper
  grammar when appropriate.
* Show ALL work for calculations in FSA format.
* You may use the References Tables for Physical Setting / Physics as well as a pen/pencil, ruler,
  protractor, and scientific calculator on this exam.
Questions 1 & 2 refer to the circuit to the right:

1) What is the equivalent resistance of the circuit? [1]
   a. 60 Ω  b. 80 Ω  c. 20 Ω  d. 13 Ω

2) If another resistor was added in series to the circuit [1]
   a. the total resistance would increase and the total current would increase
   b. the total resistance would increase and the total current would decrease
   c. the total resistance would decrease and the total current would increase
   d. the total resistance would decrease and the total current would decrease

3) Two small identical metal spheres, A and B, on insulated stands, are each given a charge of $+2.0 \times 10^6$ coulomb. The distance between the spheres is $2.0 \times 10^{-2}$ meter. Calculate the magnitude of the electrostatic force that the charge on sphere A exerts on the charge on sphere B. [2]
   a. $9.0 \times 10^{-2}$ N  b. $9.0 \times 10^{-1}$ N  c. $6.0 \times 10^{-1}$ N  d. $19.0 \times 10^{-1}$ N

4) The number of electrons that pass through a wire's cross-sectional area in an amount of time is defined as [1]
   a. electron current  b. potential difference  c. charge  d. resistance

5) Which graph best represents a metal conductor with constant resistance? [1]

6) An electric dryer consumes $6 \times 10^5$ J of energy when operating at 220 volts for 30 minutes. During operation, the dryer draws a current of approximately [2]
   a. 10 A  b. 15 A  c. 20 A  d. 25 A
Questions 7 & 8 refer to the circuit to the right:

7) The equivalent resistance of the circuit is [2]
   a. 1.0 Ω  b. 0.1 Ω  c. 110 Ω  d. 10 Ω

8) If another 20 Ω resistor was added in parallel to the circuit [1]
   a. the equivalent resistance would increase and the total current would increase
   b. the equivalent resistance would increase and the total current would decrease
   c. the equivalent resistance would decrease and the total current would increase
   d. the equivalent resistance would decrease and the total current would decrease

9) In the circuit to the right, how much charge passes through the resistor in 2 seconds? [2]
   a. 6.0 C  b. 2.0 C  c. 8.0 C  d. 4.0 C

10) If the voltage across a 12 Ω resistor is 6 volts, the current through the resistor is [2]
    a. 0.5 A  b. 78 A  c. 2 A  d. 34 A

11) The table to the right shows the length and cross-sectional area of four pieces of copper wire at the same temperature. Which wire has the highest resistance? [1]

12) An operating 75 watt lamp is connected to a 120 volt outlet. How much electrical energy is used by the lamp in an hour (3600s)? [2]
    a. 4.5 x 10^3 J  b. 2.7 x 10^3 J  c. 5.4 x 10^3 J  d. 3.2 x 10^3 J

13) Two identically-sized metal spheres on insulating stands are positioned as shown below. The two spheres are touched together and then separated. The total charge on sphere A after the separation is [1]
    a. -4.0 x 10^-6 C  b. -6.0 x 10^-6 C  c. -8.0 x 10^-6 C  d. -1.2 x 10^-6 C
14) Which net charge could be found on an object? [1]
   a.  $+4.80 \times 10^{-19}$ C
   b.  $+2.40 \times 10^{-19}$ C
   c.  $-2.40 \times 10^{-19}$ C
   d.  $-5.60 \times 10^{-19}$ C

15) If 40 joules of work is used to transfer 20 coulombs of charge through a 20-ohm resistor, the potential difference across the resistor is [2]
   a.  2 V
   b.  0.5 V
   c.  20 V
   d.  800 V

16) Which particle would produce a magnetic field? [1]
   a.  a neutral particle moving in a straight line
   b.  a neutral particle moving in a circle
   c.  a stationary charged particle
   d.  a moving charged particle

17) Which combination of resistors has the smallest equivalent resistance? [1]

   (Short answer on next page)
**Constructed Response:**

18) Draw the magnetic field lines between the two bar magnets below: [1]

\[ \text{N} \quad \text{S} \quad \text{N} \quad \text{S} \]

**Questions 19 & 20 refer to the passage & diagram below:**
A 200-kilogram car is initially at rest at point A on a roller coaster track. The car carries a 70-kilogram passenger and is 20. meters above the ground at point A. [Neglect friction.]

19) What is the potential energy of the cart/passenger system at point A? [2]

20) What is the speed of the cart/passenger system at point B? [2]

**Questions 21-23 refer to the passage & circuit diagram below:**
A 9 volt battery is connected in series to a switch a variable resistor and a light bulb. The current through ammeter A is 1.5 amps and the resistance in the light bulb (R\textsubscript{L}) is 2 Ω.

21) What is the equivalent resistance of the circuit? [2]

22) How much resistance is provided to the circuit by the variable resistor R\textsubscript{V}? [2]

23) Calculate the power of the light bulb. [2]
Questions 24 & 25 refer to the passage & circuit diagram below:
A circuit contains a 12.0-volt battery, an ammeter, a variable resistor, and connecting wires of negligible resistance, as shown below. The variable resistor is a nichrome wire, maintained at 20.0°C. The ammeter reads 2.00 amperes when the length of the wire is 10.0 centimeters.

24) Determine the resistance of the nichrome wire. [2]

25) Calculate the cross-sectional area of the nichrome wire. [2]

Questions 26-28 refer to the passage & circuit diagram below:
A 3.0-ohm resistor, an unknown resistor, $R$, and two ammeters, $A_1$ and $A_2$, are connected as shown with a 12-volt source. Ammeter $A_1$ reads a current of 5.0 amperes.

26) Determine the equivalent resistance of the circuit. [2]

27) Calculate the current measured by ammeter $A_1$. [2]

28) Calculate the resistance of the unknown resistor, $R$. [2]

29) The magnitude of the electric field strength between two oppositely charged parallel metal plates is $2.0 \times 10^3$ newtons per coulomb. Point $P$ is located midway between the plates. An electron is located at point $P$ between the plates. Calculate the magnitude of the force exerted on the electron by the electric field. [2]

30) **BONUS:** What is the total current in the circuit below? [2]
**TEST SCORE BREAKDOWN BY STANDARD**

**Student:** Example A  
**Assessment:** Unit 7 Electricity

<table>
<thead>
<tr>
<th>#</th>
<th>Standards</th>
<th>Correct Answer</th>
<th>Student Answer</th>
<th>Correct Points Earned</th>
<th>Out Of</th>
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<td>EL2 Resistance: I can determine the resistance of a wire based on its characteristics.</td>
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<td>25</td>
<td>EL2 Resistance: I can determine the resistance of a wire based on its characteristics.</td>
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<tr>
<td>4</td>
<td>EL3 Ohm's Law &amp; Current: I can relate resistance, voltage, and current.</td>
<td>a b No</td>
<td></td>
<td>0</td>
<td>1</td>
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<td>5</td>
<td>EL3 Ohm's Law &amp; Current: I can relate resistance, voltage, and current.</td>
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<td>9</td>
<td>EL3 Ohm's Law &amp; Current: I can relate resistance, voltage, and current.</td>
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<td>10</td>
<td>EL3 Ohm's Law &amp; Current: I can relate resistance, voltage, and current.</td>
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<td></td>
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<tr>
<td>24</td>
<td>EL3 Ohm's Law &amp; Current: I can relate resistance, voltage, and current.</td>
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<td>1</td>
<td>EL4 Series Circuits: I can construct and analyze a circuit with one path.</td>
<td>a a Yes</td>
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<tr>
<td>2</td>
<td>EL4 Series Circuits: I can construct and analyze a circuit with one path.</td>
<td>b a No</td>
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<tr>
<td>21</td>
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<tr>
<td>22</td>
<td>EL4 Series Circuits: I can construct and analyze a circuit with one path.</td>
<td></td>
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<tr>
<td>7</td>
<td>EL5 Parallel Circuits: I can construct and analyze a circuit with multiple paths.</td>
<td>d d Yes</td>
<td></td>
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<tr>
<td>8</td>
<td>EL5 Parallel Circuits: I can construct and analyze a circuit with multiple paths.</td>
<td>c c Yes</td>
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<tr>
<td>26</td>
<td>EL5 Parallel Circuits: I can construct and analyze a circuit with multiple paths.</td>
<td></td>
<td></td>
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<td>2</td>
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<tr>
<td>27</td>
<td>EL5 Parallel Circuits: I can construct and analyze a circuit with multiple paths.</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>EL5 Parallel Circuits: I can construct and analyze a circuit with multiple paths.</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>EL6 Electrical Energy &amp; Power: I can determine the energy expended or power used in an electrical system.</td>
<td>b b Yes</td>
<td></td>
<td>1</td>
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<tr>
<td>12</td>
<td>EL6 Electrical Energy &amp; Power: I can determine the energy expended or power used in an electrical system.</td>
<td>b b Yes</td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td>15</td>
<td>EL6 Electrical Energy &amp; Power: I can determine the energy expended or power used in an electrical system.</td>
<td>a a Yes</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>EL6 Electrical Energy &amp; Power: I can determine the energy expended or power used in an electrical system.</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>b b Yes</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>b b Yes</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>a a Yes</td>
<td></td>
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<td>1</td>
</tr>
<tr>
<td>16</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td>d d Yes</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>ES1 Conservation of Charge: I can determine how charge will move in a system and the way an object becomes charged.</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
This question addresses students understanding of the components that affect the resistance of a wire. These components include the resistivity (based on the material), length, and cross-sectional area of the wire. In question 25, students need to use the resistance equation to calculate the cross-sectional area of the wire given the other components for the equation.
**EL3**  
4, 5, 9, 10, 24  

10) If the voltage across a 12 Ω resistor is 6 volts, the current through the resistor is [2]

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>0.5 A</td>
</tr>
<tr>
<td>b.</td>
<td>78 A</td>
</tr>
<tr>
<td>c.</td>
<td>2 A</td>
</tr>
<tr>
<td>d.</td>
<td>34 A</td>
</tr>
</tbody>
</table>

This question addresses students' knowledge of ohm's law on a very simplistic level. Students must know the relationship between voltage, current, and resistance in simplistic terms in order to be able to solve this equation for the current given the other two variables.

**EL4**  
1, 2, 21, 22  

Questions 21-23 refer to the passage & circuit diagram below:
A 9 volt battery is connected in series to a switch a variable resistor and a light bulb. The current through ammeter A is 1.5 amps and the resistance in the light bulb (R₁) is 2 Ω.

21) What is the equivalent resistance of the circuit? [2]

22) How much resistance is provided to the circuit by the variable resistor R₂? [2]

This standard is a bit more complicated. For these two questions, students are given a series circuit and need to evaluate various components of it including the equivalent resistance and the resistance provided by one resistor. Students cannot solve this problem without recognizing that current must stay the same in a series circuit while voltage decreases over each component. Resistors must be added to find equivalent resistance. Students will also need to apply Ohm’s Law to this circuit to complete the solution.

**EL5**  
7, 8, 26, 27, 28
For these three questions, students are given a parallel circuit and need to evaluate the components of it using what they know to be true of all parallel circuits. Students cannot solve this problem for equivalent resistance, current, and resistance of one resistor without recognizing that the voltage stays the same in each leg of the circuit while the current adds as it has to split up to go through the junction. In order to find equivalent resistance, the inverse of each resistor is added up and then the inverse of the total is taken. Students will also need to apply Ohm’s Law to this circuit to complete the solution.

To answer this question, students must understand the relationship between the components of a circuit, namely voltage and time, to the energy of the circuit and the power that will be generated from the circuit. Students must recognize that they need to use the power equations and use the components given to choose the equation that best relates to the scenario. In this case, students will want to be using power times time equals work oh, thus ignoring the voltage.
The following reflection document for students is located on google forms to increase accuracy and quick evaluation of data. This reflection will be completed by students upon receiving their exams back the day after the assessment. Prior to retaking any portion of the assessment, students must complete this form as well as the re-teach questions document on the previous page to ensure increased depth of understanding.

Students can access this survey through nearpod.com and using the following code. The survey is self-paced and will send student feedback too me when they are finished. The survey includes a number of questions (also listed below) with a mix of polls (multiple choice) and open ended response.

Join with this CODE at Nearpod.com or in the app

PMGLW

Valid from Mon, Nov 4th 2019 until Wed, Dec 4th 2019
29 days remaining

Nearpod Reflection Document:

OPTICS REFLECTIONS
Which standard was most difficult for you, based on your assessment score?

- A. EL1
- B. EL2
- C. EL3
- D. EL4
- E. EL5
- F. EL6

What were some of your main misconceptions/areas of confusion when it came to your understanding of the standard you previously selected? Be specific!
If you plan to retake a second standard, which one will it be?

- A. EL1
- B. EL2
- C. EL3
- D. EL4
- E. EL5
- F. EL6

What will you do prior to taking the retake assessment to ensure you have deepened your understanding of these concepts? Select all that apply.

- A. Utilize Castle Learning questions for this standard
- B. Meet with Mrs. Carbone to discuss questions
- C. Read topic and answer sample questions on Classroomphysics.com
- D. Create flashcards to memorize terms and units that caused confusion
- E. Watch videos on this topic at khan academy to deepen understanding
- F. Go through notes
- G. Other
What did you enjoy most or find most helpful during the waves unit? (Be Specific) If there was one thing you would change about the waves unit or a piece of feedback you would give to Mrs. Carbone, what would it be?
A foundational aspect of standards based grading is assessing whether or not students have grasped each standard and the depth of their understanding. However research shows that, particularly in science, a handwritten assessment such as a classical test addresses a select number of misconceptions and can only account for a portion of the students understanding. A focus in the science world has been on application of content beyond the typical classroom setting. Thus, as a further assessment of students understanding of electricity and the six standards associated with it in this unit, students will complete and in-depth, hands on application and evaluation project. Completing this project will show that students have a deep understanding of the content as it applies to the three-dimensional world in which we live. The final project requires students to apply their knowledge of the standards, as well as their own ingenuity, as they figure out how to create their own headphone using simple supplies that can be connected to their phone’s headphone jack.

This particular project requires students to follow directions to create a headphone. This headphone will demonstrate how energy is transferred in the process of bringing music from your phone into your ear. Students will see how moving electrons create electric current as well as magnetic fields, both of which are necessary to have a successful speaker. Furthermore, students will be challenged by the exactness to which they need to spin their wire and will see how significant small components are in electronic devices.

Completing this project requires students to address each of the six standards associated with electricity. These standards will be addressed not only and how they create their own instrument and the sound that it makes but also in their written reflection addressing each of the concepts. The depth of learning is significantly increased when students can apply that learning directly to an application.

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**Electricity Application Project:**

**Headphones Project**

**Goals:**

- Model the transfer of energy between a power source, conducting wire, and in sound.

- Describe the connection between electrical currents and magnetic forces / fields.

- Investigate the production and transfer of sound.

<table>
<thead>
<tr>
<th>EL1</th>
<th>____/5</th>
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<tbody>
<tr>
<td>EL2</td>
<td>____/5</td>
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<td>EL4</td>
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<td>EL5</td>
<td>____/5</td>
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<tr>
<td>EL6</td>
<td>____/5</td>
</tr>
<tr>
<td>TOT</td>
<td>____/20</td>
</tr>
</tbody>
</table>

---
Making a Speaker: Follow the directions carefully to create your speaker!

- Cut a strip of paper from the cardstock that is 1-2 cm wide. Wrap it tightly around a magnet (strong, neodymium), making a small cylinder.

- Tape down the end of the strip of paper to itself to secure the cylinder.

- Using a second strip of paper, make another cylinder wrapped around the outside of the first, again using tape to hold it in place.

- Remove the magnet and inner cylinder using a pen or pencil.

- Tape down the outer cylinder to the center of an index card.

- Tape one side of a piece of magnet wire (insulation burned off at both ends) to the index card, then tightly wrap the magnet wire around the now taped-down cylinder, leaving about 3 inches unwrapped on both sides of the wire.

- Connect an alligator clip to each of the ends of the wire, which make up two ends of a standard headphone jack cable (one left channel, one right).

- Place some staples inside a paper cup, and then attach the magnet to the bottom of the cup, which should be attracted to the staples.

- Finally, flip the index card over and place the cup on the index card so that the magnet is directly above the wire-covered cylinder. Plug your headphone-jack into a music device, and give it a listen!
**Model:** Now, draw a picture of your model and write a short description detailing how you believe it works and what is happening at a microscopic level!
Analysis Questions:

1) Describe in a well-written paragraph how your headphones are working on a molecular level. Be sure to discuss electricity, current, and energy transfer.

2) How well did your model work as a speaker? Were you surprised or not surprised?

3) Using your model, describe how the electrical current is interacting with the magnet to produce the intended effect in your speaker:

4) Sound is transmitted through sound waves. In your model, describe how these waves are produced and where they might be coming from:

5) Starting with the music playing device, describe how energy is transferred in your speaker model to its final destination. Be as specific and detailed as possible!
Re-take Assessment for Module #7: Electricity

Name: ____________________________

Electricity Test RETAKE

**ES1 and WE5**

1) What is the magnitude of the electrostatic force exerted on an electron by another electron when they are 0.10 meter apart?
   
   1. $2.6 \times 10^{-6}$ N
   2. $2.3 \times 10^{-7}$ N
   3. $2.3 \times 10^{-8}$ N
   4. $1.4 \times 10^{-9}$ N

2) Two small metallic spheres, $A$ and $B$, are separated by a distance of $4.0 \times 10^{-1}$ meter, as shown. The charge on sphere $A$ is $+5.0 \times 10^{-6}$ coulomb and the charge on sphere $B$ is $-8.0 \times 10^{-6}$. If the spheres are brought together so that they touch and then are moved apart, what is the charge on each sphere?

3) Which net charge could not be found on an object? [1]
   
   1. $+1.0 \times 10^{-19}$ C
   2. $+1.6 \times 10^{-19}$ C
   3. $-4.8 \times 10^{-19}$ C
   4. $-6.4 \times 10^{-19}$ C

4) A magnetic field would be produced by a beam of [1]
   
   1. electrons
   2. gamma rays
   3. x-rays
   4. neutrons

5) Which statement describes the polarity of magnetic poles $A$ and $B$?
   
   1. $A$ is a north pole and $B$ is a south pole.
   2. $A$ is a south pole and $B$ is a north pole.
   3. Both $A$ and $B$ are north poles.
   4. Both $A$ and $B$ are south poles.

6) The magnitude of the electric field strength between two oppositely charged parallel metal plates is $2.5 \times 103$ newtons per coulomb. Point $P$ is located midway between the plates. A proton is located at point $P$ between the plates. Calculate the magnitude of the force exerted on the proton by the electric field. [2]
7) A 450-kilogram car is initially at rest at point A on a roller coaster track. The car carries a 70-kilogram passenger and is 100 meters above the ground at point A. [Neglect friction.]

   a. What is the speed of the cart/passenger system at point B? [2]

   b. What is the speed of the cart/passenger system at point C? [2]

EL2

8) Which combination of resistors has the smallest equivalent resistance? [1]

1. 

2. 

3. 

4. 

9) *A circuit contains a 12.0-volt battery, an ammeter, a variable resistor, and connecting wires of negligible resistance, as shown below. The variable resistor is a tungsten wire, maintained at 20.0°C. The ammeter reads 4.00 amperes when the length of the wire is 20.0 centimeters.

   a. Determine the resistance of the 20.0-centimeter length of Tungsten wire. [2]

   b. Calculate the cross-sectional area of the Tungsten wire. [2]
10) A metal conductor is used in an electric circuit. The electrical resistance provided by the conductor could be decreased by [1]

1. Increasing the length of the conductor
2. Increasing the applied voltage to the circuit
3. Increasing the temperature of the conductor
4. Increasing the cross sectional area of the conductor

11) What is the resistance of a 50.0-meter-long tungsten rod with a cross-sectional area of $2.00 \times 10^{-4}$ meter$^2$ at 20°C? [1]

1. $1.40 \times 10^{-2}$ Ω
2. $2.8 \times 10^{-2}$ Ω
3. 89.3 Ω
4. 112 Ω

EL3

12) The amount of work it takes to move a unit of charge [1]

1. electron current 
2. potential difference
3. charge
4. resistance

13) Which graph represents the relationship between the potential difference applied to a copper wire and the resulting current in the wire at constant temperature?

1.

3.

14) A circuit contains a 12.0-volt battery, an ammeter, a variable resistor, and connecting wires of negligible resistance, as shown below. The variable resistor is a tungsten wire, maintained at 20.0°C. The ammeter reads 4.00 amperes when the length of the wire is 20.0 centimeters. Determine the resistance of the tungsten wire. [2]
EL3 (continued)

15) If the voltage across a 6 Ω resistor is 12 volts, the current through the resistor is [1]
   1. 0.5 A   2. 3.78 A   3. 2 A   4. 4.34 A

16) In the circuit to the right, how much charge passes through the resistor in 4 seconds?
   1. 16.0 C   2. 2.0 C   3. 8.0 C   4. 4.0 C

17) When only one lightbulb blows out, the rest of the string of decorative lights stays on. The lights in this string must be connected in [1]
   1. parallel with one current pathway
   2. parallel with multiple current pathways
   3. series with one current pathway
   4. series with multiple current pathways

18) If another resistor was added in series to the circuit [1]
   1. the total resistance would increase and the total current would increase
   2. the total resistance would increase and the total current would decrease
   3. the total resistance would decrease and the total current would increase
   4. the total resistance would decrease and the total current would decrease

19) What is the current through the 10.-ohm resistor? [1]
   1. 0.25 A   2. 6.0 A   3. 12 A   4. 4.0 A

20) A student constructed a series circuit consisting of a 12.0-volt battery, a 15.0-ohm lamp, an unknown resistor, and an ammeter to measure current. When the circuit is operating, the total current measured at the ammeter is 0.75 ampere.
   a. Calculate the power consumed by the circuit. [2]

   b. What is the resistance of the unknown resistor? [2]
EL5

Questions 21-23 refer to the following circuit:

21) The total resistance of the circuit is [1]
   1. 1.5 Ω  2. 0.625 Ω
   3. 4.8 Ω  4. 13 Ω

22) If the 2 Ω resistor were to be removed from the circuit [1]
   1. the equivalent resistance would increase and the total current would increase
   2. the equivalent resistance would decrease and the total current would decrease
   3. the equivalent resistance would decrease and the total current would increase
   4. the equivalent resistance would increase and the total current would decrease

23) Which of the three resistors would have the least amount of current flowing through it? [1]
   1. 1 Ω
   2. 2 Ω
   3. 10 Ω
   4. The current would be equal in all resistors

24) A 20.-ohm resistor, $R_1$, and a resistor of unknown resistance, $R_2$, are connected in parallel to a 30.-volt source, as shown in the circuit diagram below. An ammeter in the circuit reads 2.0 amperes.

   a. What is the potential difference across the 20-ohm resistor? [2]

   b. Calculate the current flowing through the 20-ohm resistor. [2]

   c. Determine the equivalent resistance of the circuit [2]

   d. Calculate the resistance of resistor $R_2$. [2]
25) The total amount of electrical energy used by a 120 V toaster drawing a current of 2 A for 90 seconds is: [1]
   1. 180 J  
   2. 5400 J  
   3. 240 J  
   4. 21600 J

26) If 80 joules of work is used to transfer 20 coulombs of charge through a 40-ohm resistor, the potential difference across the resistor is [1]
   1. 2 V  
   2. 0.25 V  
   3. 4 V  
   4. 1600 V

27) A 122 volt battery is connected in series to a switch a variable resistor and a light bulb. The current through ammeter A is 5.5 amps and the resistance in the light bulb (R_L) is 4 Ω.
   a. Calculate the power of the light bulb. [2]

   b. An operating 60 watt lamp is connected to a 120 volt outlet. How much electrical energy is used by the lamp in one day? [2]

28) Which graph represents the relationship between the resistance on a copper wire and the resulting power in the wire at constant potential difference? [1]
Example of Gradebook Snapshot for Module #7: Electricity

Performance Level Grading Scale for Standards Based Grading

The following chart is an example of a performance and standard grading system. Rather than scoring students on a 100 point (percentage) scale, where students receive an exact number of points that is somewhat arbitrary, this performance scale allows for a score that is both simplified and indicative of the student’s actual success understanding a standard. The 4.0 is the highest point value a student can achieve and it represents full and advanced understanding of a standard. The other performance grades are listed as well. The value of this scale comes in its simplicity and meaning for students. For example, receiving a 3.0 on a particular standard tells the student that they are approaching a depth of understanding and with a couple corrections to misconceptions they can bring that score up. This allows for students to constantly strive for depth of understanding on each standard. They have the option to attempt to master the standard through the various assessments until they achieve a 4.0. The scales makes student’s grades less about numbers, after all, what is the difference in an 87% and an 89% in terms of student understanding? Students should be able to quickly interpret their weak and strong skills from this numbering system.

<table>
<thead>
<tr>
<th>Performance Level grade</th>
<th>Percent Equivalent</th>
<th>Meaning</th>
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</thead>
<tbody>
<tr>
<td>4.0</td>
<td>100</td>
<td>Advanced Performance and deep understanding of standard</td>
</tr>
<tr>
<td>3.5</td>
<td>95</td>
<td>Understanding of standard</td>
</tr>
<tr>
<td>3.0</td>
<td>85</td>
<td>Approaching understanding of standard</td>
</tr>
<tr>
<td>2.0</td>
<td>75</td>
<td>Some foundational understanding of standard</td>
</tr>
<tr>
<td>1.0</td>
<td>55</td>
<td>Little to no understanding of standard</td>
</tr>
</tbody>
</table>

Gradebook Snapshot for Standards Based Grading

The following table is a snapshot of what a gradebook may look like for this particular unit. Students should be able to look into the gradebook and see a quick summary of the standards as well as their current understanding of the standards based on assessments. Each assignment represents some form of assessment on a particular assignment (lab, quiz, test, etc.) and the students demonstrated performance level. The ‘a’ and ‘b’ after the standard symbolize multiple assessments that tested that particular standard. This allows students to see progress on each standard through time as well as areas to improve. Notice the grades are all utilizing the performance level grading scale shown in the table above. In terms of grade calculations, a 4.0 in the gradebook will equate to a 100% factored into a student’s grade while a 2.0 equates to a 75%. This allows for the use of standards based grading to inform students and simplify grades, while also still fitting into a system that relies on percentage scores for final grades.
Sample of Gradebook for Electricity:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>EL1</th>
<th>EL2a</th>
<th>EL2b</th>
<th>EL3a</th>
<th>EL3b</th>
<th>EL4a</th>
<th>EL5a</th>
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<tr>
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</table>


