Teaching at Worcester Technical High School

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Abstract

This paper documents my growth over the course of four months as a student teacher. I spent fifteen weeks at Worcester Technical High School teaching physics. During this time, I learned first-hand about the unique responsibilities of teachers. Described in this work is the Massachusetts education system and my place within it. Specifically, evidence of my growth as an educator through a discussion of the six elements of CAP, candidate assessment of performance. These elements include well-structured lesson plans, adjustment to practice, meeting diverse needs, creating a safe learning environment, maintaining high expectations and, reflective practice. Each of these elements is essential to effective teaching and while complete mastery is seldom met, I experienced tremendous growth in each of these areas as a result of my student teaching experience. In addition to a discussion of these elements, I have included an analysis of how my education at Worcester Polytechnic Institute influenced me as an educator as well as samples of student work, lesson plans and, student feedback.

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Chapter 1: Background

The purpose of this section is to provide an overview of the context in which I completed my student teaching. Below is a summary of education within Massachusetts followed by a more narrow view of education, specifically focusing on Worcester Technical High School. This analysis of student performance and demographics at Worcester Technical High School is followed by a discussion of the specific courses I took over at Worcester Technical High School and their composition.

1.1 Massachusetts Performance in Education

In 1983 the National Commission on Excellence in Education released a report on the United States public education system. This document, titled *A Nation at Risk*, brought to light the shortcomings of public education within the U.S. (Center for the Study 2005). This report set in motion a series of reforms aimed at improving the state of the public education system. One decade after the initial release of *A Nation at Risk*, Massachusetts enacted reform aimed at doing just that. This reform came in the form of a law titled the Massachusetts Education Reform Act, or MERA (Chester 2014).

In order to tackle the perceived decline in the quality of public education, the Massachusetts Education Reform Act created new expectations for student performance. These expectations primarily called for higher performance as measured by statewide assessments (Chester 2014). Efforts such as MERA within Massachusetts have been proven successful. In 2014, Massachusetts was ranked first within the United States in overall academic proficiency based on data from the ACT, College Board, and US Chamber of Commerce Foundation’s annual Leaders and Laggards state-by-state report card. Additionally, it was found that results of the Trends in International Mathematics and Science Study (TIMSS) would rank Massachusetts eighth-graders second only to top-ranked Singapore in global measures of science competency (Crotty 2014). This is significant as overall scores within the United States often place the U.S. somewhere around 11th out of 39 countries (TIMSS 2015).

1.2 Worcester Technical High School

Worcester Technical High School is a public high school with 1,389 students as of the 2016-2017 academic year. Of these students, 57.4% are female while 42.6% are male. With regards to race, 37.1% of these students are white, 36.8% are Hispanic, 16.6% are African American, 6.6% are Asian and, 3% of students identify as multiple non-Hispanic races. Worcester Tech has a higher percentage of Hispanic and African American students than the state average for public schools. However, these percentages are on par with data for the Worcester school district (Worcester Technical 2017).

When it comes to academics, students at Worcester Tech tend to perform higher than state averages. In Spring 2017, a higher percentage of grade ten students at Worcester Tech received proficient or higher on the English Language Arts, Mathematics and, Science and Tech/Engineering MCAS than students statewide. Notably, 98% of students received a grade of proficient or higher in English Language Arts compared to the state average of 91%. Additionally, 82% of students at Worcester Tech received a grade of proficient or higher in Science and Tech/Engineering compared to the 74% state average (Worcester Technical 2017).

At Worcester Tech less than 1% of students drop out. In the 2015-2016 academic year, only 5 of the 1,358 students present at the school dropped out. In the 2013-2014 academic year 67.3% of students who graduated went on to attend a college or university (Worcester Technical

2017). This is slightly lower than the 69.7% national average, but relatively high when you consider that a portion of the programs at Worcester Tech are designed to prepare students to enter the workplace upon graduation (69.7 percent 2017).

1.3 My Place at Worcester Tech

For my teaching practicum, I worked under Jackie Kalisz at Worcester Technical High School. Ms. Kalisz teaches four physics classes. Inclusion Physics, College Physics, Honors Physics and, AP Physics. Of these courses, I took over Ms. Kalisz's Inclusion, College and, Honors Physics classes. Inclusion Physics is a class of 25 students. A portion of these students have individualized education programs (IEPs) and there is an aid in the class to help facilitate learning. The College Physics class is the smallest of Ms. Kalisz's classes at 20 students. This class primarily contains students who have historically struggled with science. Lastly, there is Ms. Kalisz’s Honors Physics class. At 29 students, this class is large. The purpose of this Honors Physics course is to provide students who would excel in College Physics the opportunity learn physics concepts more in depth.

Inclusion Physics, College Physics and, Honors Physics follow the same state standards. These standards are set by the Massachusetts Department of Elementary and Secondary Education. My teaching begins with Momentum. Topics that follow include Thermal Energy, Simple Harmonic Motion, Waves and, Electricity and Magnetism. These subjects are covered under PS 2-2, 2-3, 2-4, 2-5, 2-9, 3-1, 3-4, 3-5, 4-1, 4-3 and, 4-5.

Chapter 2: Essential Elements of CAP - Well-Structured Lesson Plans

Well-structured lesson plans are defined under the Candidate Assessment of Performance (CAP) as an essential element of effective teaching. The purpose of this section is to illustrate the importance of well-structured lesson plans. First, this chapter introduces lesson planning and its role in education, followed by an analysis of my lesson planning experiences and growth.

2.1 Educating with Well-Structured Lesson Plans

Developing well-structured lesson plans is a crucial step toward becoming an effective educator. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be deemed proficient in developing well-structured lesson plans once they are able to create plans with “challenging, measurable objectives and appropriate student engagement strategies, pacing, sequence, activities, materials, resources, technologies, and grouping.” (Guidelines for the Candidate 2016). While teaching often results in many unexpected turns, it is crucial that educators create a plan for delivering their content effectively.

Behind every strong teacher is a strong planner. This is unknown to most but is nonetheless true. Tasked with introducing a new subject to a diverse set of students within a short period of time, teachers must possess the ability to identify relevant content and present it to students in a matter that is engaging. It is said that the average attention span for a student ages 10 to 14 is between 10 and 12 minutes (Vawter 2009). This is significant as school days are often made up of eight periods approximately 45 minutes in length. Therefore, maintaining the 10-12 minute attention span as true, teachers must switch up the classroom activities at least four times to keep their students focused. Aware of this fact, strong educators incorporate a variety of activities into their lesson plans in order to maintain student focus while presenting content.

2.2 Educating at Worcester Tech with Well-Structured Lesson Plans

As a first-time teacher, creating well-structured lesson plans is a major challenge. The lesson plans I created, a portion of which are shown in appendices A, B, C, and D, were modified from Grant Wiggins and Jay McTighe. The guidelines provided by this template were extremely helpful in easing some of the challenges a student teacher might face as they plan. When creating each of my lessons, I was reminded of the Massachusetts standards specific to the topic at hand. Then, with these standards in mind, I developed an overarching objective for the lesson. This process aided greatly as I attempted to organize my thoughts. Following the initial steps of identifying relevant content, my planning would transition to organizing the content into manageable sections with the incorporation of practice and informal assessment to gauge student learning.

My early lesson plans followed a regimented schedule, shown in appendices A and B. Monday-Wednesday would consist of content presentation and practice. Since each of my classes were double periods, the first period I would have a PowerPoint prepared. This PowerPoint was used as a method for content delivery and students were expected to take notes. The second period, students would be given a worksheet related to the new content. Thursday would be a lab and Friday there would be review and a quiz. While my early lesson plans which followed this format were effective in delivering content, they lacked spontaneity, thereby minimizing student engagement. As I continued to teach and plan, I began to identify methods of content presentation most appealing to students. As a result, I began to develop lesson plans that incorporated a variety of activities and opportunities for students to prove their knowledge. For example, the lesson shown in appendix D incorporates a hands-on activity to reinforce student learning and appendices M, N and, O contain a sample alternative assessment that involved writing an informational memo. Overall, I found including these diverse activities and methods of assessment helped increase lesson effectiveness and positive student response.

One challenge of lesson planning that continually plaques teachers is timing. At the start of my student teaching, it felt impossible to predict the time needed for each task. Aware of this challenge and faced with the fear of “dead time” in the classroom, I began to develop a plan b for each of my classes. This “plan b” could be anything from additional practice problems to requiring students work on test corrections. No matter the task, inclusion of such tasks in my lessons as time permitting options helped to maximize class time and ensure every student was continually productive. By incorporating these “time permitting” tasks as well as hands-on activities and alternative assessments, my lesson plans greatly improved over the course of my student teaching experience and I, along with my students greatly benefitted as a result.

Chapter 3: Essential Elements of CAP - Adjustments to Practice

Adjustments to practice is defined under CAP as an essential element of effective teaching. The purpose of this section is to illustrate the importance of adjusting your practices an educator. First, this chapter introduces adjustments to practice within the context of education, followed by an analysis of personal experiences in adjusting my practice as an educator.

3.1 Adjusting Practices as an Educator

Adjusting one's practice is a crucial step toward becoming an effective educator. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be defined as proficient in adjusting their practices once that teacher "organizes and analyzes results from a variety of assessments to determine progress toward intended outcomes and uses these findings to adjust practice and identify and/or implement appropriate differentiated interventions and enhancements for students." (Guidelines for the Candidate 2016).

There is little consistency in the life of an educator. Each year, unit, week, period and student is different. As a result, teachers must constantly adjust their methods in order to ensure students learn, no matter the circumstances. Assessments are a major component of adjusting practice. Through a variety of formal and informal assessments, educators can identify areas in need of modification. Such insight into student perspectives allows educators to consider their actions and modify such to better meet the ever-changing needs of their students.

3.2 Adjusting Practices at Worcester Tech

Teaching at Worcester Technical High School offers a unique opportunity when it comes to adjusting one's practice. At Worcester Tech, students complete a vocational program in addition to their academic classes. To accomplish this, students alternate between academic and shop work each week. As a result, one week I had one group of students and the next week I had another group of students. Therefore, I would carry out an entire week's worth of lessons then repeat those lessons with a new group of students. This unique schedule allowed me to revisit lessons I already taught and modify them to better meet student needs. This paired with continual adjustments based on immediate student response greatly improved my ability to present content and plan lessons.

In addition to general student response to content, assessments played a key role in my adjustments to practice. Throughout any given week, students would be given a number of informal assessments. The purpose of these assessments was to help me, as a teacher, gauge student learning. Over time, I recognized the value of assessments and developed expectations based on student exposure to content. My expectations were as follows:

1. Students may struggle with calculations or concepts when they begin the first informal assessment, but through practice and review, students can answer questions without major difficulty. It is when students show a great deal of confusion that clarification is required.
2. After completing a number of informal assessments throughout the week, students practice their knowledge with a review. At this point, students are expected to demonstrate near complete understanding of content and seek help where needed.
3. Finally, students are given a summative assessment where they are expected to show complete understanding of content.

Developing this progression of expectations surrounding assessments helped inform me on student progress as well as help to identify where adjustments were needed.

Beyond adjustments based on personal performance, teachers also benefit from observing other teachers and learning from them. The value in this became most apparent to me through a professional development seminar held by the STEM Education Center at WPI. Participants in this seminar consisted of both experienced and student teachers. I found this to be extremely beneficial as it generated diverse responses in discussions and activities. In one design activity, student teachers were separated from experienced teachers and instructed to create a lesson framework for a specific topic. Once complete, the student teachers' lesson was vastly different than the experienced teachers'. The experienced teachers decided the topic was conducive to a hands-on activity involving rotating stations. Comparatively, I, along with my peers, relied on the more standard approach of content presentation and note-taking. This experience reminded me of the value in varying viewpoints and the consequent importance of considering these viewpoints when adjusting one's practice.

Chapter 4: Essential Elements of CAP - Meeting Diverse Needs

Meeting diverse needs is defined under CAP as an essential element of effective teaching. The purpose of this section is to illustrate the importance of meeting diverse needs. First, this chapter introduces meeting diverse needs within the context of education, followed by an analysis of personal experiences and growth when aiming to meet diverse student needs.

4.1 Meeting Diverse Needs as an Educator

In order to be an effective educator, one must recognize and aim to meet the diverse needs of their students. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be defined as proficient in meeting diverse needs once that teacher "uses appropriate practices, including tiered instruction and scaffolds, to accommodate differences in learning styles, needs, interests, and levels of readiness, including those of students with disabilities and English language learners." (Guidelines for the Candidate 2016).

Meeting diverse needs is a particularly challenging, but necessary element of teaching. This challenge is so great because diversity comes in many shapes. While simply looking at a student body can offer some insight into racial and cultural diversity, diversity is more than skin deep. As an educator, one must consider an individual's personal experiences, learning preferences, abilities and the unique needs that accompany such characteristics. Therefore, when faced with twenty or more individuals in one room, one should expect those individuals to each carry a unique set of needs.

4.2 Meeting Diverse Needs at Worcester Tech

During my student teaching experience at Worcester Tech, I was tasked with educating 75 students on a variety of physics topics. Of these students, 20 were in my college physics class, 30 in my honors physics class and 25 in my inclusion physics class. Broadly, each of these classes required unique modifications in order to meet the unique needs of the class as a whole. Additionally, within each class, every student possessed a unique set of needs, which I was required to accommodate as their educator. When applicable, such needs are identified and documented in that specific student's Individualized Education Plan (IEP).

Early in my student teaching, I reviewed the IEPs of my students. My college class had four students involved in special education (SPED) and five English language learners (ELLs). My honors class had seven students involved in special education and eight ELLs. Lastly, my inclusion class had eleven students involved in special education and ten ELLs. In order to accommodate such a diverse group of students a number of practices were set in place.

First, and perhaps most importantly, I offered my students access to me outside of the classroom. From the start of my student teaching, I was available to students via Schoology, an online learning management system where students can review their grades and send messages to their teacher. However, many students used this platform minimally. Thus, after a few weeks of teaching, I began to advertise days in which I would be staying after school and free periods in which students could stop by with questions or concerns. Over time I discovered this availability encouraged students to seek help and feel more comfortable in doing so.

Second, considering student needs while creating lesson plans helped set the tone for meeting student needs in the classroom. As I developed as a planner and educator, I began to recognize where in my plans I could accommodate the specific needs of my students and ensure they do not fall behind in the lesson. For example, each definition posted on the board was read aloud and explained. This provided ELLs the opportunity to better understand a word’s meaning and its role in the topic at hand.

Finally, maintaining patience served me a great deal, particularly with SPED students and ELLs. Many of my special education students’ and ELLs IEPs included accommodations such as direction clarification, extra time to complete tasks and periodic assessment of progress. Each class, I followed through with these accommodations for my students. I would calmly repeat directions, clarify concepts, and check in with students to ensure consistent productivity. This, paired with accommodations taken into consideration while lesson planning, helped me to serve the needs of diverse populations within my classroom increasingly over time. For samples of ELL and SPED student work, see appendices H and K respectively.

Chapter 5: Essential Elements of CAP - Safe Learning Environment

Fostering a safe learning environment is defined under CAP as an essential element of effective teaching. The purpose of this section is to illustrate the importance of creating a safe learning environment. First, this chapter introduces creating a safe learning environment within the context of education, followed by an analysis of personal experiences and growth when aiming to create a safe learning environment for students.

5.1 Creating a Safe Learning Environment as an Educator

Creating a safe learning environment is a crucial step toward becoming an effective educator. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be defined as proficient in creating a safe learning environment once that teacher “uses rituals, routines, and appropriate responses that create and maintain a safe physical and intellectual environment where students take academic risks and most behaviors that interfere with learning are prevented.” (Guidelines for the Candidate 2016).

Creating a safe space for students is essential for student success. By fostering an environment in which students feel comfortable enough to share ideas, students are able to better build their knowledge of subject matter as well as skills applicable outside of the classroom. Accomplishing such safe space is not an easy task and success can vary year-to-year. However, for the well-being of students, it is essential that educators consider their environment and how it is affecting student learning.

5.2 Creating a Safe Learning Environment at Worcester Tech

There are many layers that make up the atmosphere of any given classroom. There are interactions between teacher and students, students and content, and interactions between the students themselves. While it is impossible to be conscious of all interactions, in order to create a safe learning environment, teachers should aim to be cognizant of their own behavior and tone in the classroom.

At the start of my student teaching, I was frequently surprised by where my students felt challenged. Whether this was as a result of educational gaps or difficulty maintaining focus, I struggled early on to hide my surprise and concern regarding my students’ prior education. For example, in my second week of teaching, I learned that many of the students in my inclusion class struggle with completing simple calculations to solve for an unknown. I was taken off guard by this and responded to my students in a way that could have made them feel insecure applying their math knowledge in my class. However, as one might expect, I have come a long way since my second week of teaching. By the end of my student teaching experience, I noticed a significant increase in the number of students seeking help and greater positivity from students regarding their individual abilities.

Also crucial to creating a safe-space is promoting positive interactions between students. I struggled a great deal in this department with my inclusion class. There were a number of prior and ongoing conflicts between students of this class and while I learned to distract students with content, there was one student in particular who gave me trouble. This student has a number of required accommodations as outlined in their IEP. These accommodations include increased response and processing time, task break down and, periodic checking and progress assessment. For the purpose of describing interactions with this student further, I will refer to them as B.

Early in my teaching, I found B to be very pleasant. Respectful during one-on-one interactions and quiet, though sometimes rowdy with friends. However, after some time I noticed signs of B bullying others when my back was turned. This became more apparent after I was approached by a concerned student. I had placed this student next to B in an assigned seating arrangement and after only one class the student requested a seating change. Provided this new information I revisited my seating chart and was faced with a challenge. I needed to find students to place next to B that B would feel comfortable around, without encouraging negative behavior. Those same students must also have the confidence to stand up to B, without causing major conflict. After some trial and error, I found a place for B which appeared to work. Yet, it seemed

B’s behavior shifted. B became more withdrawn and unfocused in class. It seemed I had improved the relationship with all of my students except B. With B, I seemed to have moved backward.

After some time in their assigned seating arrangement, student behavior overall improved. The class was more engaged, focused and infinitely more productive. Noticing this behavior, I decided to reward the students by allowing them to choose their own groups for a lab activity. During this time, I noticed B became more sociable. Noticing this, I deliberately engaged with B and B’s groupmates, asking about their progress and any questions they might have. B was far more willing to ask questions and engage while amongst the familiarity of friends. This gave me hope as B seemed to learn that positive behavior would yield a positive response. After this time, B’s personal focus improved. B became more concerned with their own behavior and whether or not they might be awarded the opportunity to redeem their previous behavior.

While B is only one of many students I was responsible for in my student teaching, I felt their case clearly exemplifies the importance of considering how one might foster a safe environment for all students. While my primary concern was to promote a positive environment in my class overall, individual students have needs that require unique attention. B helped me to figure this out. Therefore, just as much as B challenged and confused me, B also offered some insight into what students crave from their classroom environment. Whether that be the comfort of friends as in B’s case, support from me, or simply a systematic environment in which they can explore themselves and the world around them.

Chapter 6: Essential Elements of CAP - High Expectations

Maintaining high expectations is defined under CAP as an essential element of effective teaching. The purpose of this section is to illustrate the importance of high expectations and their role in the classroom. First, this chapter introduces high expectations within the context of education, followed by an analysis of personal experiences and growth when aiming to uphold high expectations in the classroom.

6.1 Maintaining High Expectations as an Educator

Maintaining high expectations is a crucial step toward becoming an effective educator. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be defined as proficient in maintaining high expectations once that teacher “effectively models and reinforces ways that students can master challenging material through effective effort, rather than having to depend on innate ability.” (Guidelines for the Candidate 2016).

It is essential that educators sustain high expectations for all students. This is so essential as lowering expectations for students for any reason is a disservice to that student. Rather, each student must be awarded equal opportunity to succeed. Educators can ensure this is accomplished by offering students support and accommodations wherever needed but never lowering expectations to meet student performance. While this remains true, maintaining high expectations can be challenging when one's students are separated by prior academic performance.

6.2 Maintaining High Expectations at Worcester Tech

At Worcester Tech I took over three classes, College Physics, Honors Physics and Inclusion Physics. Each class was governed by the same state standards and therefore the same overarching expectations. However, student response to the content differed greatly. When I was first exposed to these classes I was surprised that there was no content difference between the three classes. I knew I would need to challenge the students in each of my classes, but this seemed difficult when the students picked up the content at drastically different paces. Initially, I set on a pace that was too slow for most of the honors students, slightly too fast for most of the college students and clearly too fast for most of the inclusion class. This was discouraging as I was unsure how I could manipulate my expectations for one class and not the others. I struggled with this for some time until I considered content breadth vs. depth.

So often in American public schools, content is covered broadly without deep explanation or contextualization. While efforts have been taken to combat this, it is still apparent in most cases. In my personal experience as a student teacher, I realized that this broad approach to education could appropriately service my college and inclusion classes with the integration of more in-depth concepts where appropriate. While my honors class would greatly benefit from a greater challenge through in-depth discovery. I accomplished this balance through trial and error, oftentimes supplementing the assigned work in every class with additional topics for the honors students. Success in this department came with time and is clearly represented in the overall success of my students.

In addition to the challenge of maintaining high expectations across different classes, I also found it challenging to maintain high expectations for students after they had missed class. I struggled with this with one student in particular. For the purposes of describing this student further, I will refer to them as C. Early in my student teaching experience, C was absent for an entire week of school due to medical reasons. Concerned for their education, I frequently made offers to meet with C after school or during free periods in order to catch them up. However, between seeing this student every other week, additional absences and C neglecting to show up to scheduled meetings, I was questioning the feasibility of C making up missed work before the end of the quarter. Nevertheless, I persisted, likely pestering the student at times to ensure the student was given ample opportunity to make up their work. Though this student was unable to pass this quarter due to incomplete and unsatisfactory work, I was pleased with my decision to maintain my expectations for C upon meeting with C’s aunt.

After grades were closed, C's aunt requested a meeting with C's teachers. During this meeting, I learned my class was not the only one C neglected to make up work in. After C had missed an entire week of class, C continually neglected their work and skipped classes at times to avoid such work. At this meeting, each teacher shared their hopes for C as they began the new quarter. During this time I realized that if I had lowered my expectations for C, it would have reinforced their behavior instead of discouraging it. Further, from this meeting, I learned that family can act as a motivator for students in their education. While students may not always listen to the adults in their lives, approaching an individual with concern and hope rather than discouragement can change behavior for the better. These lessons in the importance of maintaining high expectations helped me best serve my students, thereby strengthening my performance as an educator.

Chapter 7: Essential Elements of CAP - Reflective Practice

Reflective practice is defined under CAP as an essential element of effective teaching. The purpose of this section is to illustrate the importance of reflection. First, this chapter introduces reflective practice within the context of education, followed by an analysis of personal experiences and growth through reflection.

7.1 Reflecting as an Educator

Reflection is a crucial step toward becoming an effective educator. As defined by the Massachusetts Department of Elementary and Secondary Education, a teacher can be defined as proficient in reflective practice once that teacher “regularly reflects on the effectiveness of lessons, units, and interactions with students, both individually and with colleagues, and uses insights gained to improve practice and student learning.” (Guidelines for the Candidate 2016).

As with any profession, teaching requires constant reflection. In order to improve, one must consider their past and how adjustments can be made to yield a more positive result. Educators must constantly reflect on their practices in order to identify effective and ineffective teaching methods. This practice is particularly crucial for educators as student response can differ class-to-class and year-to-year. Therefore, each day, week, month and year, teachers should reflect on their methods and consider where adjustments are needed.

7.2 Reflecting as an Educator at Worcester Tech

As mentioned previously, Worcester Tech has a unique approach to education. Faced with a schedule that results in teachers seeing each class every other week, teachers are given ample opportunity to reflect on their actions in any given week then apply any adjustments with a new student body. This method of education greatly promotes reflective practice for educators. After my first week of teaching, I considered all notes I had made regarding things I wish I had done differently and applied them to my class the following week to the best of my ability, see appendices A and B for lesson plans. However, thrust into an environment of minimal comfort, it is easy to forget mental notes made while reflecting on one’s actions.

While repeating a lesson to a new group of students can promote reflective practice, one may also fall into a routine without reflection. As a student teacher, you are overwhelmed with new information. While learning how to lesson plan, manage a classroom, and communicate effectively you must also continually evaluate your progress, which can be exhausting. Therefore, reflecting on my actions as a teacher fell by the wayside at times during my student teaching experience. More often, I relied on comments from observers than personal reflection. It is difficult to pinpoint the moment where this shifted for me, but a great shift did occur during my student teaching experience, likely around the time I received explicit student feedback.

About halfway through my time as a student teacher, I provided my students with a feedback survey, see appendix P for survey questions. The purpose of this survey was to gather insight into the student view and facilitate reflection based on this perspective. From this data I realized that each class differed in terms of their needs (complete feedback data can be seen in appendix Q). While common themes were present in the overall data, it became apparent that I should be continually reflecting on my performance in each individual class as well as my overall performance as an educator. Upon this revelation, I began to repeatedly reflect while considering the unique needs of each of my classes in areas outlined by the student survey results, and beyond.

By the end of my student teaching experience, I found myself modifying my plans between classes based on student response from the period before. Further, I would recall student responses to specific content presentation methods while I planned for upcoming lessons in order to teach most effectively. This constant reflection benefitted each of my classes uniquely over time, greatly contributing to my growth and development as an educator.

Chapter 8: My WPI Education

The purpose of this section is to discuss how my education at WPI influenced my performance as a teacher. Specifically, this section details the tools acquired through education-related courses intended to prepare me for teaching as well as courses outside the field of education which similarly shaped my approach to teaching.

8.1 Courses in Education

Teaching Methods in Math and Science was my first formal introduction to teaching. Having spent the majority of my life on the student side of education, I was unsure of what to expect with this course. Now, I would describe this class as a crash course to teaching. Covering topics such as lesson planning, implicit bias, grading, classroom management, and professionalism, this course provides a snapshot into the world of teaching. It is through this course that I became aware of the importance of educators as role models, support, and cheerleaders for students.

Within one term at WPI, I was enrolled in both School Psychology and Sheltered English Immersion. As one might expect, I noticed a great deal of overlap between these courses. However, while my course in School Psychology focused on the importance of early education and creating effective learning environments, Sheltered English Immersion dealt with incorporating English language learning in all courses. Activities for this course often involved developing lesson plans or activities that would support ELLs, a skill that is extremely helpful in a culturally diverse school such as Worcester Tech.

Most recently, I participated in a Cognitive Psychology course at WPI. This course provided valuable insight into the way the human mind works. Chiefly, the applicability of this course lay within studies of long-term and short-term memory. In this course, we discussed how memory works, what humans are best at remembering, and ways individuals can transfer information into their long-term memory. Such methods include: relating information to oneself, generating questions based on the information and testing oneself, all of which could be incorporated into lessons to help students retain information over time.

8.2 Explicit Interdisciplinary Applications in the Classroom

It is not always easy to translate classroom education into experiences in the "real world". However, given first-hand experiences applying coursework to "real world” scenarios, educators can more effectively engage their students. Having spent the majority of their lives in formal education, students are disconnected in some ways from field applications of their coursework. This truth often results in students asking the question, “What does anybody use this stuff for?” As someone who followed their interest in physics and math to a major in civil engineering, I have some answers to this question.

Oftentimes, when creating my lesson plans I would begin by reading standards and asking myself, “Where might these concepts be useful?” Then, I could create a plan surrounding those ideas by including relevant examples, activities, and assessments. By creating a setting in which course content can be applied, students are typically more engaged and interested in completing and understanding deliverables. However, I say “typically” because there are a number of students who struggle to maintain focused, or feel the “real world” applications are not relevant in their world. In order to engage these students, I consider my position as a student at WPI.

Student teachers get to experience the unique opportunity of learning along with their students. While teaching my students, I was in the process of learning concepts associated with my coursework at WPI as well as effective teaching strategies. It is through this unique position that I was able to consider how my most effective professors were able to succeed as educators then adapt their methods to engage my students. This was often most effective when dealing with students who struggled to maintain engaged no matter the content.

Although I found the ability to apply content knowledge and effective teaching methods from my WPI courses helpful when educating students, I found that broader concepts I learned through my WPI education to be most beneficial when aiming to prepare my students for the remainder of their high school career and life after.

8.3 Broad Interdisciplinary Applications in the Classroom

If I have learned anything in my time at WPI, it is that all topics are interconnected. Oftentimes, in elementary and secondary education topics are broken into subjects, science, history, math, etc. Yet, in the “real world” a combination of the skills is required to succeed. For example, in math and science courses, students are often taught how to approach a problem logically to discover a technical solution. However, when approaching a problem realistically, one must consider the social, environmental, and economic impact in addition to technical feasibility. This concept became most clear to me through a combination of civil engineering and environmental studies courses.

In my sophomore year at WPI, I participated in a series of civil engineering courses surrounding structural analysis and design. Oftentimes in these courses, I participated in projects where a "client" had a design request and I was expected to test the feasibility of that request and reply to the client in a clear, professional manner. In pursuing a degree in civil engineering I had not expected my math-based courses to require any formal writing. However, through these assignments, I became aware of the importance of developing a diverse set of skills so they may be applied when appropriate. This concept is supported by the popular phrase, “if all you have is a hammer, everything looks like a nail.” What this means is when you are only aware of one way to tackle a problem, you will use that method even when it is not appropriate.

In addition to developing diverse skills, it is crucial that an individual possesses the ability to consider multiple perspectives. This year, I participated in a number of civil and environmental studies courses on the topic of land use and development. Through these courses, I was forced to consider social, environmental, and economic constraints surrounding land use. Specifically, when decisions are made regarding how a particular piece of land should be used, there are a plethora of stakeholders who are each affected differently. Depending on the situation, it is possible a development could degrade the natural environment and cause decreased property values for abutters while the community as a whole could experience economic gain. In a situation such as this, there is no simple solution. However, by possessing the ability to consider varying perspectives, a most educated decision can be made.

My belief in the importance of diversified skills and outlooks has made me a stronger educator all around. In terms of preparation, this knowledge allowed me to create effective lesson plans that incorporated a variety of skills to strengthen the students' abilities and promote confidence when dealing with unfamiliar concepts. Similarly, my ability to see a situation from varying viewpoints allowed me to be a more compassionate and thereby effective teacher. As mentioned in section 8.4, the use of real-world examples in my courses at WPI was helpful in answering the question of "what does anybody use this stuff for?" This was certainly useful in my experience as a teacher. However, I believe incorporating lessons in diversifying skill-sets and perspectives was most beneficial to my students in my class and as they move on to live professional lives.

Chapter 10: Conclusion

Now that my student teaching experience has come to a close I can conclude this: teaching is an extremely challenging task. There is limited consistency in the life of the teacher period-to-period, week-to-week, and year-to-year. I consider this to be one of the greatest challenges of teaching, but also what makes it appealing. Not knowing how students will respond any given day always kept me on my toes, something I learned to enjoy over time. Though I did come to appreciate this over time, the greatest growth I personally observed dealt with my personality as a teacher.

At the start of student teaching experience, I was nervous about whether or not I would be able to build a relationship with my students. As a fairly quiet individual, I feared I would be a withdrawn and uninteresting educator. Early in my teaching, I might consider this to be true. However, as I built my confidence and comfort in the classroom, I began to expose my personality more frequently and I noticed the same from my students. Experiencing this was a tremendous reward for all my hard work planning, revising and carrying out lessons. By the end of my teaching experience, I felt as though I had taught my students effectively, and without boring them to death.

I would not have accomplished all that I did as a student teacher without the support from my fellow student teachers as well as established teachers. From the position of a student, teaching may appear to be a profession in which one works with complete independence. This is far from true. Not only are there standards to guide students, but the most successful teachers are well connected with their colleagues. These connections provide teachers with the support to better themselves in their careers and provide the best education to their students.

Further, this experience affirmed a belief I developed on the student-side of education. This belief was that teachers can make or break a student’s academic experiences. Teachers possess a great power that is to not be taken lightly. This paper emphasized six essential elements of successful teaching and while those elements contribute greatly to student success, there is an unlimited number of teaching components that impact the level of student learning. It is through a consistent willingness to improve that an educator might understand the elements of teaching and how to best serve their students.

I would like to conclude this piece considering my future as an educator. If I were to teach again tomorrow, I would aim to challenge each of my students through coursework while providing them with the support to reach the high expectations I set for them. I would opt for this goal because if I have learned anything from my student teaching experience it is that a student is shaped by their in-class experiences. Therefore, if I can enlist confidence and pride in my students, they will be vastly more successful in all future endeavors.

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Appendix A – Week 1 Day 1 Lesson Plan

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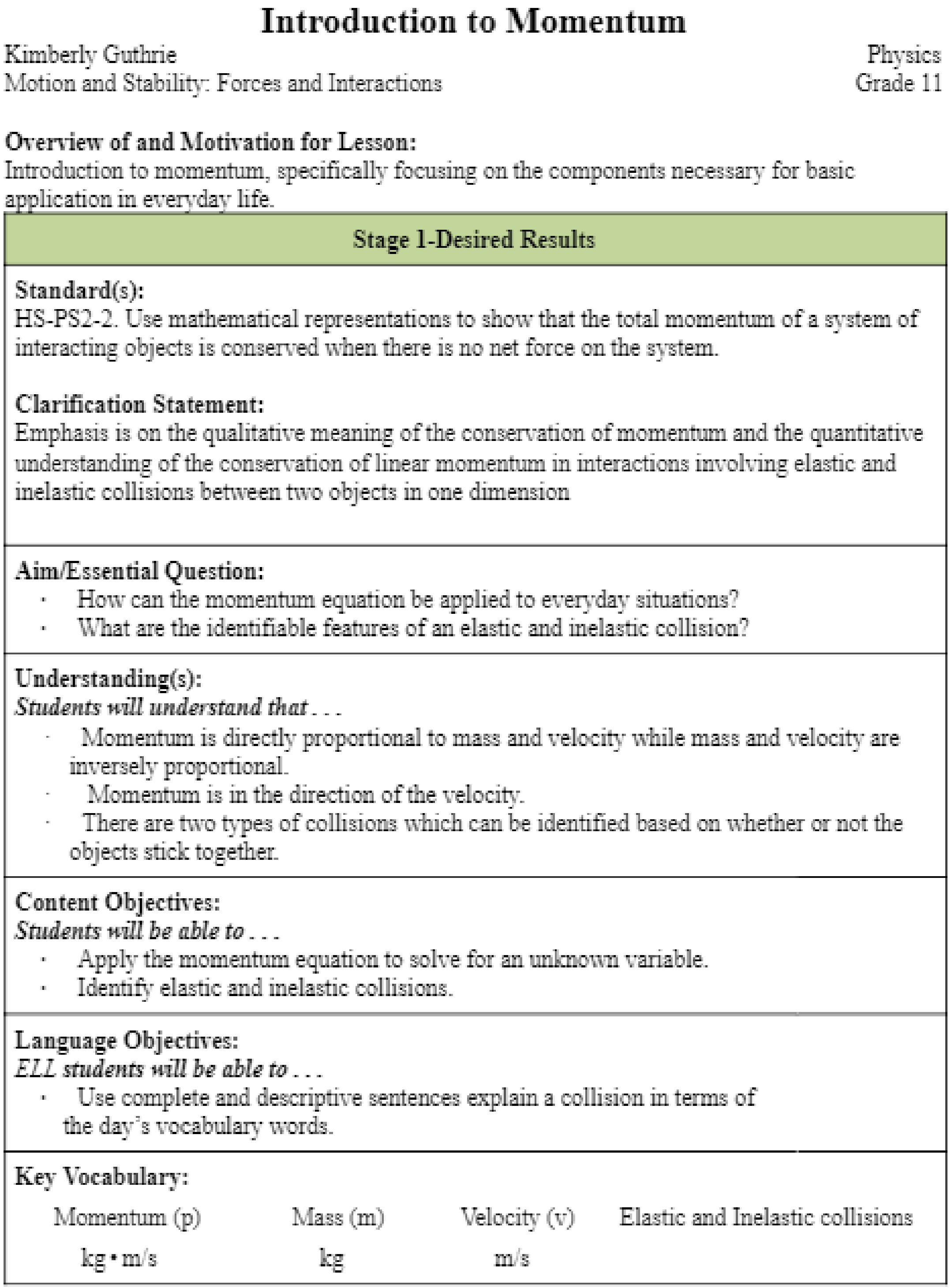


Introduction to Momentum

Kimberly Guthrie — Physics
Motion and Stability: Forces and Interactions — Grade 11

Overview of and Motivation for Lesson:
Introduction to momentum, specifically focusing on the components necessary for basic application in everyday life.

Stage 1-Desired Results

Standard(s):
HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.

Clarification Statement:
Emphasis is on the qualitative meaning of the conservation of momentum and the quantitative understanding of the conservation of linear momentum in interactions involving elastic and inelastic collisions between two objects in one dimension

Aim/Essential Question:
- How can the momentum equation be applied to everyday situations?
- What are the identifiable features of an elastic and inelastic collision?

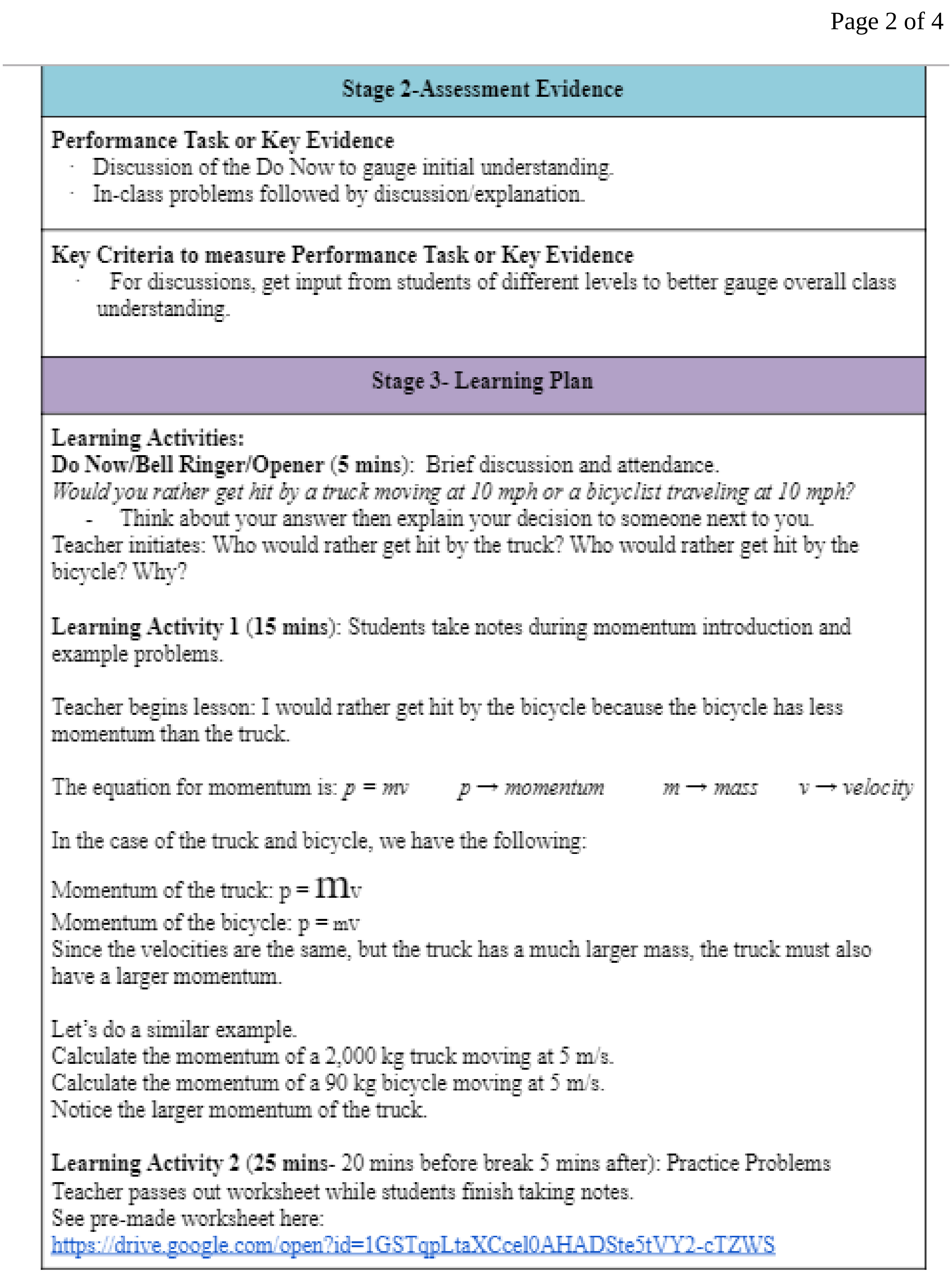
Understanding(s):
Students will understand that . . .
- Momentum is directly proportional to mass and velocity while mass and velocity are inversely proportional.
- Momentum is in the direction of the velocity.
- There are two types of collisions which can be identified based on whether or not the objects stick together.

Content Objectives:
Students will be able to . . .
- Apply the momentum equation to solve for an unknown variable.
- Identify elastic and inelastic collisions.

Language Objectives:
ELL students will be able to . . .
- Use complete and descriptive sentences explain a collision in terms of the day's vocabulary words.

Key Vocabulary:

Momentum (p)	Mass (m)	Velocity (v)	Elastic and Inelastic collisions
kg • m/s	kg	m/s	



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Stage 2-Assessment Evidence

Performance Task or Key Evidence

- Discussion of the Do Now to gauge initial understanding.
- In-class problems followed by discussion/explanation.

Key Criteria to measure Performance Task or Key Evidence

- For discussions, get input from students of different levels to better gauge overall class understanding.

Stage 3- Learning Plan

Learning Activities:
Do Now/Bell Ringer/Opener (**5 mins**): Brief discussion and attendance.
Would you rather get hit by a truck moving at 10 mph or a bicyclist traveling at 10 mph?

- Think about your answer then explain your decision to someone next to you.

Teacher initiates: Who would rather get hit by the truck? Who would rather get hit by the bicycle? Why?

Learning Activity 1 (**15 mins**): Students take notes during momentum introduction and example problems.

Teacher begins lesson: I would rather get hit by the bicycle because the bicycle has less momentum than the truck.

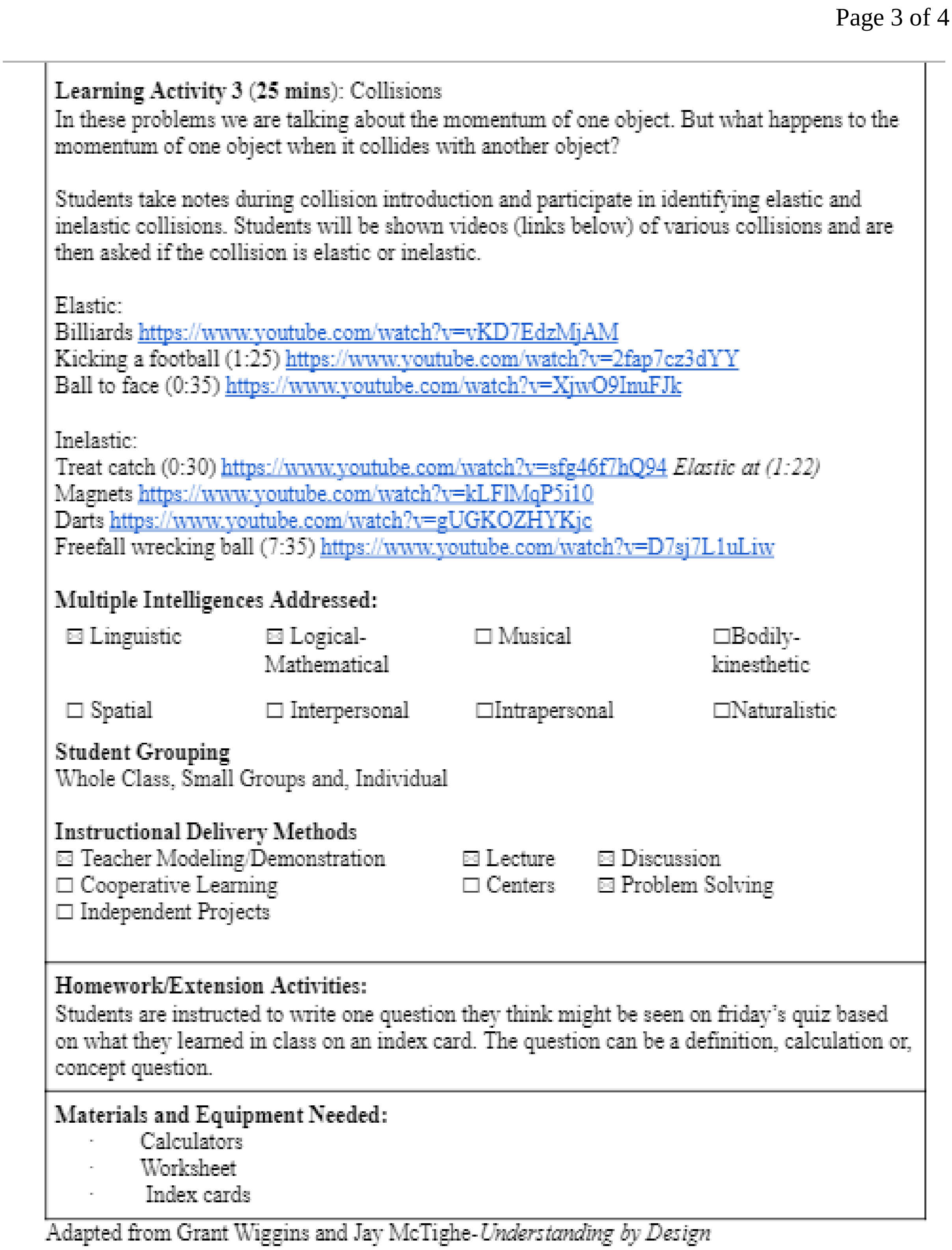
The equation for momentum is: $p = mv$ $p \rightarrow$ *momentum* $m \rightarrow$ *mass* $v \rightarrow$ *velocity*

In the case of the truck and bicycle, we have the following:

Momentum of the truck: $p = {\Large m}v$
Momentum of the bicycle: $p = {\scriptsize m}v$
Since the velocities are the same, but the truck has a much larger mass, the truck must also have a larger momentum.

Let's do a similar example.
Calculate the momentum of a 2,000 kg truck moving at 5 m/s.
Calculate the momentum of a 90 kg bicycle moving at 5 m/s.
Notice the larger momentum of the truck.

Learning Activity 2 (**25 mins**- 20 mins before break 5 mins after): Practice Problems
Teacher passes out worksheet while students finish taking notes.
See pre-made worksheet here:
https://drive.google.com/open?id=1GSTqpLtaXCcel0AHADSte5tVY2-cTZWS



Learning Activity 3 (25 mins): Collisions
In these problems we are talking about the momentum of one object. But what happens to the momentum of one object when it collides with another object?

Students take notes during collision introduction and participate in identifying elastic and inelastic collisions. Students will be shown videos (links below) of various collisions and are then asked if the collision is elastic or inelastic.

Elastic:
Billiards https://www.youtube.com/watch?v=vKD7EdzMjAM
Kicking a football (1:25) https://www.youtube.com/watch?v=2fap7cz3dYY
Ball to face (0:35) https://www.youtube.com/watch?v=XjwO9InuFJk

Inelastic:
Treat catch (0:30) https://www.youtube.com/watch?v=sfg46f7hQ94 *Elastic at (1:22)*
Magnets https://www.youtube.com/watch?v=kLFlMqP5i10
Darts https://www.youtube.com/watch?v=gUGKOZHYKjc
Freefall wrecking ball (7:35) https://www.youtube.com/watch?v=D7sj7L1uLiw

Multiple Intelligences Addressed:

☒ Linguistic
☐ Spatial

☒ Logical-Mathematical
☐ Interpersonal

☐ Musical
☐Intrapersonal

☐Bodily-kinesthetic
☐Naturalistic

Student Grouping
Whole Class, Small Groups and, Individual

Instructional Delivery Methods
☒ Teacher Modeling/Demonstration
☐ Cooperative Learning
☐ Independent Projects

☒ Lecture
☐ Centers

☒ Discussion
☒ Problem Solving

Homework/Extension Activities:
Students are instructed to write one question they think might be seen on friday's quiz based on what they learned in class on an index card. The question can be a definition, calculation or, concept question.

Materials and Equipment Needed:

- Calculators
- Worksheet
- Index cards

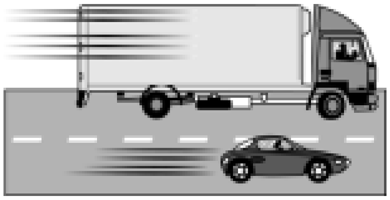
Adapted from Grant Wiggins and Jay McTighe-*Understanding by Design*

Name: ______________________ Date: ______________

PRACTICE 3.1

Momentum

READ



Which is more difficult to stop: A tractor-trailer truck barreling down the highway at 35 meters per second, or a small two-seater sports car traveling the same speed?

You probably guessed that it takes more force to stop a large truck than a small car. In physics terms, we say that the truck has greater *momentum*.

We can find momentum using this equation:

$$\text{momentum} = \text{mass of object} \times \text{velocity of object}$$

Velocity is a term that refers to both speed and direction. For our purposes we will assume that the vehicles are traveling in a straight line. In that case, velocity and speed are the same.

The equation for momentum is abbreviated like this: $p = m \times v$.

Momentum, symbolized with a *p*, is expressed in units of kg·m/sec; *m* is the mass of the object, in kilograms; and *v* is the velocity of the object in m/sec.

PRACTICE

Use your knowledge about solving equations to work out the following problems:

1. If the truck has a mass of 2,000 kilograms, what is its momentum? Express your answer in kg·m/sec.
2. If the car has a mass of 1,000 kilograms, what is its momentum?
3. An 8-kilogram bowling ball is rolling in a straight line toward you. If its momentum is 16 kg·m/sec, how fast is it traveling?
4. A beach ball is rolling in a straight line toward you at a speed of 0.5 m/sec. Its momentum is 0.25 kg·m/sec. What is the mass of the beach ball?
5. A 4,000-kilogram truck travels in a straight line at 10.0 m/sec. What is its momentum?
6. A 1,400-kilogram car is also traveling in a straight line. Its momentum is equal to that of the truck in the previous question. What is the velocity of the car?
7. Which would take more force to stop in 10 seconds: an 8.0-kilogram ball rolling in a straight line at a speed of 0.2 m/sec or a 4.0-kilogram ball rolling along the same path at a speed of 1.0 m/sec?
8. The momentum of a car traveling in a straight line at 20 m/sec is 24,500 kg·m/sec. What is the car's mass?
9. A 0.14-kilogram baseball is thrown in a straight line at a velocity of 30 m/sec. What is the momentum of the baseball?
10. Another pitcher throws the same baseball in a straight line. Its momentum is 2.1 kg·m/sec. What is the velocity of the ball?
11. A 1-kilogram turtle crawls in a straight line at a speed of 0.01 m/sec. What is the turtle's momentum?

Appendix B – Week 2 Day 1 Lesson Plan

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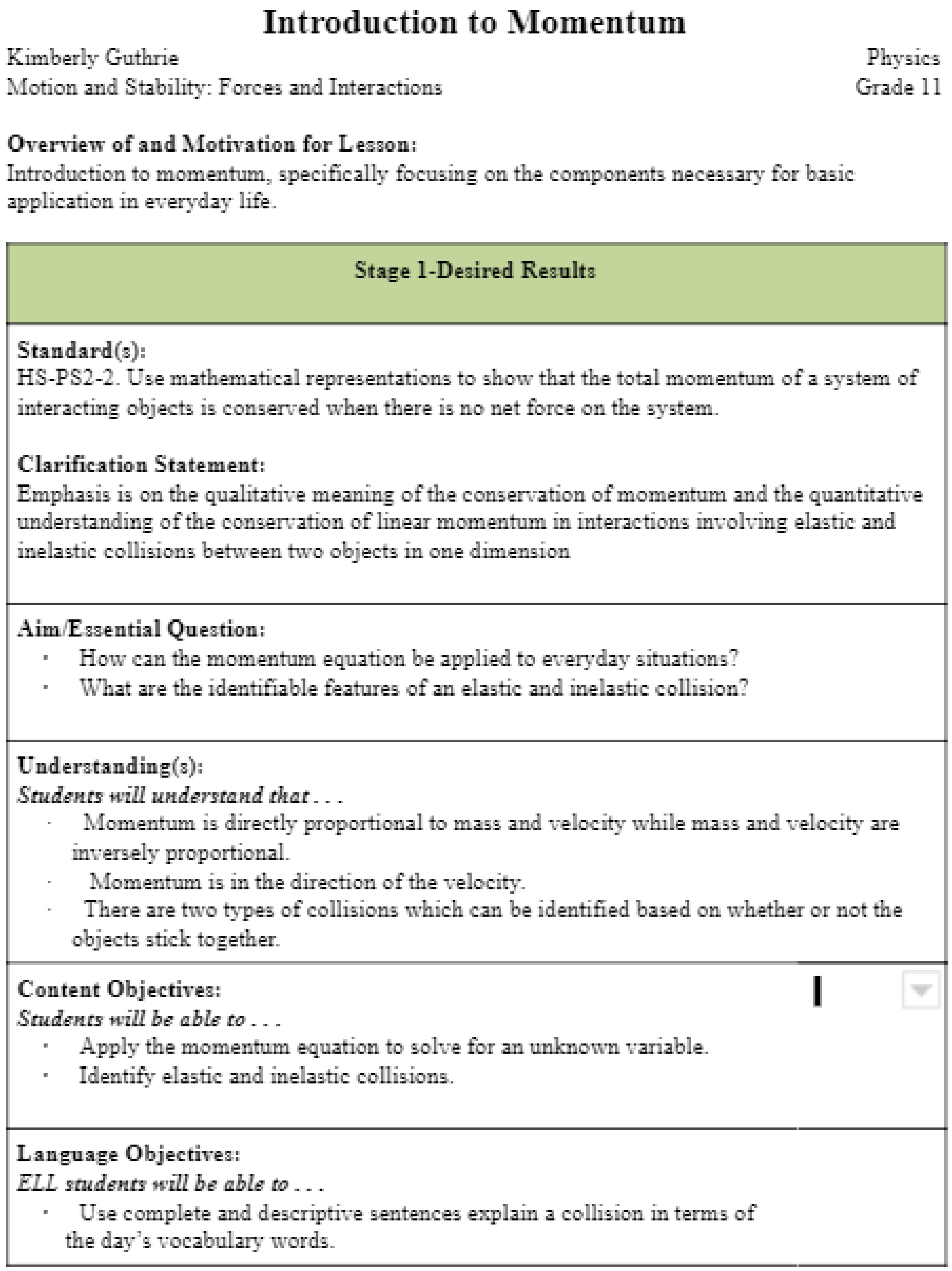


Introduction to Momentum

Kimberly Guthrie | Physics
Motion and Stability: Forces and Interactions | Grade 11

Overview of and Motivation for Lesson:
Introduction to momentum, specifically focusing on the components necessary for basic application in everyday life.

Stage 1-Desired Results

Standard(s):
HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.

Clarification Statement:
Emphasis is on the qualitative meaning of the conservation of momentum and the quantitative understanding of the conservation of linear momentum in interactions involving elastic and inelastic collisions between two objects in one dimension

Aim/Essential Question:

- How can the momentum equation be applied to everyday situations?
- What are the identifiable features of an elastic and inelastic collision?

Understanding(s):
Students will understand that . . .

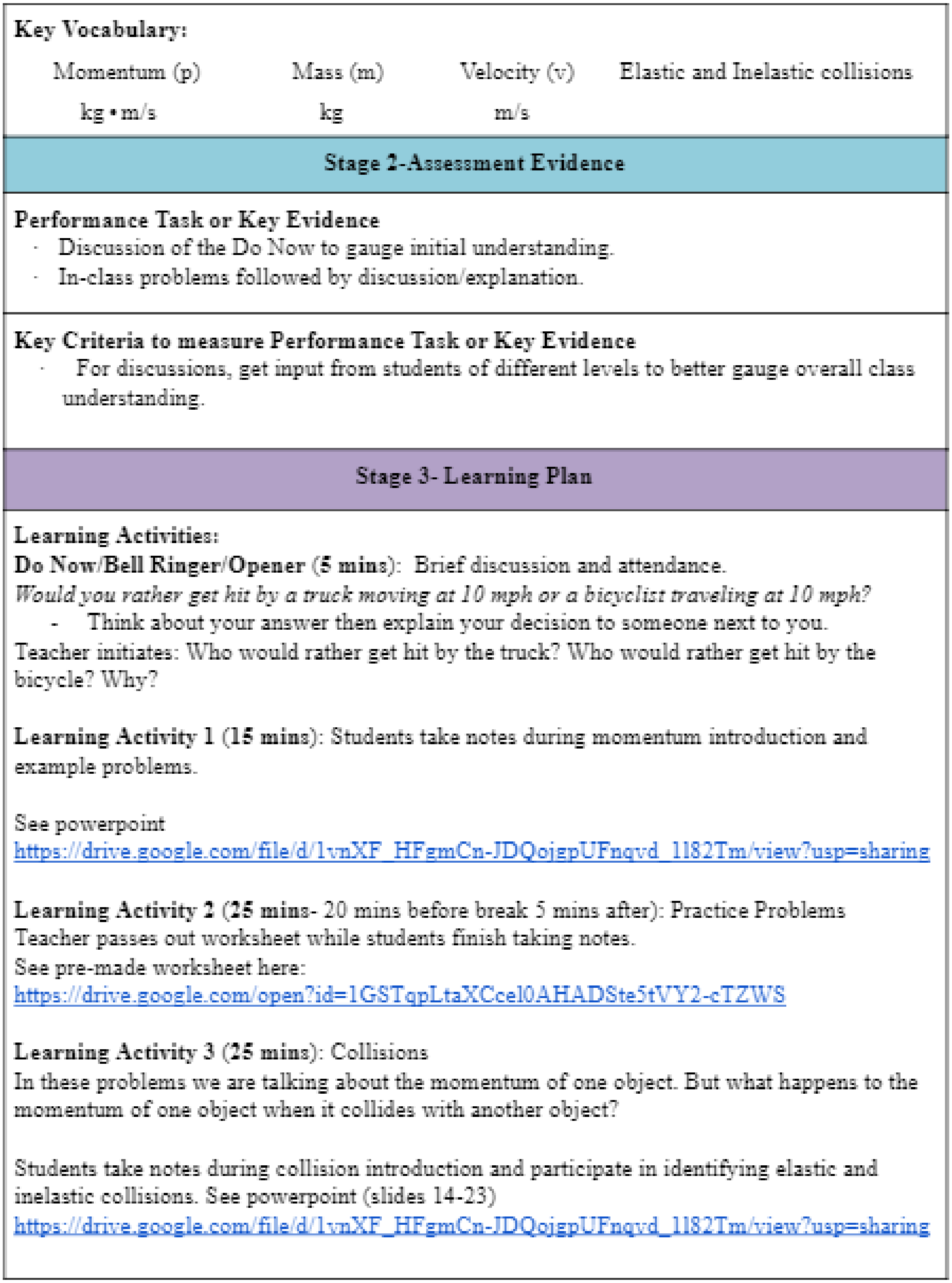
- Momentum is directly proportional to mass and velocity while mass and velocity are inversely proportional.
- Momentum is in the direction of the velocity.
- There are two types of collisions which can be identified based on whether or not the objects stick together.

Content Objectives:
Students will be able to . . .

- Apply the momentum equation to solve for an unknown variable.
- Identify elastic and inelastic collisions.

Language Objectives:
ELL students will be able to . . .

- Use complete and descriptive sentences explain a collision in terms of the day's vocabulary words.



Key Vocabulary:

Momentum (p)	Mass (m)	Velocity (v)	Elastic and Inelastic collisions
kg • m/s	kg	m/s	

Stage 2-Assessment Evidence

Performance Task or Key Evidence

- Discussion of the Do Now to gauge initial understanding.
- In-class problems followed by discussion/explanation.

Key Criteria to measure Performance Task or Key Evidence

- For discussions, get input from students of different levels to better gauge overall class understanding.

Stage 3- Learning Plan

Learning Activities:

Do Now/Bell Ringer/Opener (5 mins): Brief discussion and attendance.

Would you rather get hit by a truck moving at 10 mph or a bicyclist traveling at 10 mph?

- Think about your answer then explain your decision to someone next to you.

Teacher initiates: Who would rather get hit by the truck? Who would rather get hit by the bicycle? Why?

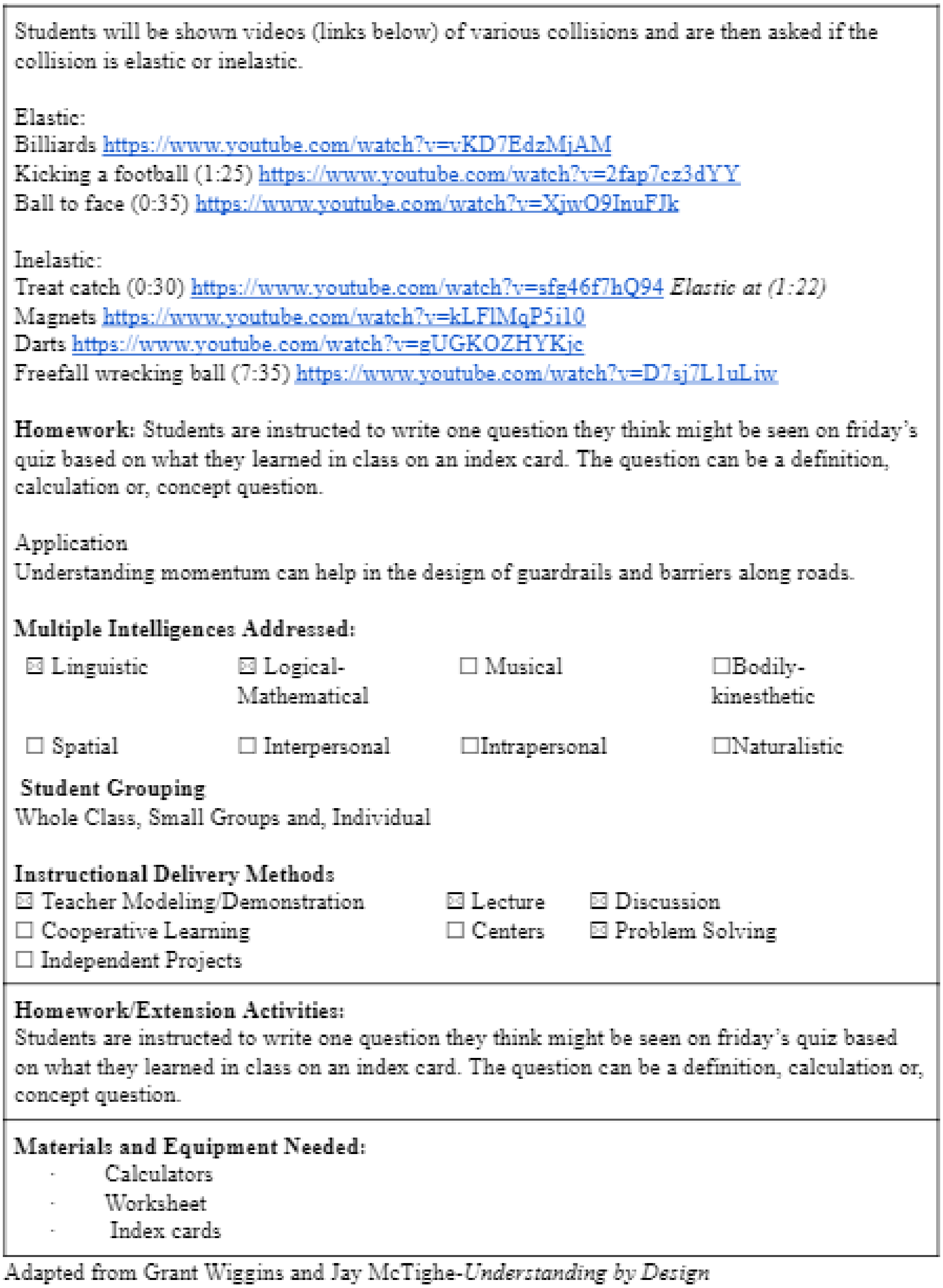
Learning Activity 1 (15 mins): Students take notes during momentum introduction and example problems.

See powerpoint
https://drive.google.com/file/d/1vnXF_HFgmCn-JDQojgpUFnqvd_1l82Tm/view?usp=sharing

Learning Activity 2 (25 mins- 20 mins before break 5 mins after): Practice Problems
Teacher passes out worksheet while students finish taking notes.
See pre-made worksheet here:
https://drive.google.com/open?id=1GSTqpLtaXCcel0AHADSte5tVY2-cTZWS

Learning Activity 3 (25 mins): Collisions
In these problems we are talking about the momentum of one object. But what happens to the momentum of one object when it collides with another object?

Students take notes during collision introduction and participate in identifying elastic and inelastic collisions. See powerpoint (slides 14-23)
https://drive.google.com/file/d/1vnXF_HFgmCn-JDQojgpUFnqvd_1l82Tm/view?usp=sharing



Students will be shown videos (links below) of various collisions and are then asked if the collision is elastic or inelastic.

Elastic:
Billiards https://www.youtube.com/watch?v=vKD7EdzMjAM
Kicking a football (1:25) https://www.youtube.com/watch?v=2fap7cz3dYY
Ball to face (0:35) https://www.youtube.com/watch?v=XjwO9InuFJk

Inelastic:
Treat catch (0:30) https://www.youtube.com/watch?v=sfg46f7hQ94 *Elastic at (1:22)*
Magnets https://www.youtube.com/watch?v=kLFlMqP5i10
Darts https://www.youtube.com/watch?v=gUGKOZHYKjc
Freefall wrecking ball (7:35) https://www.youtube.com/watch?v=D7sj7L1uLiw

Homework: Students are instructed to write one question they think might be seen on friday's quiz based on what they learned in class on an index card. The question can be a definition, calculation or, concept question.

Application
Understanding momentum can help in the design of guardrails and barriers along roads.

Multiple Intelligences Addressed:

☒ Linguistic
☒ Logical-Mathematical
☐ Musical
☐Bodily-kinesthetic
☐ Spatial
☐ Interpersonal
☐Intrapersonal
☐Naturalistic

Student Grouping
Whole Class, Small Groups and, Individual

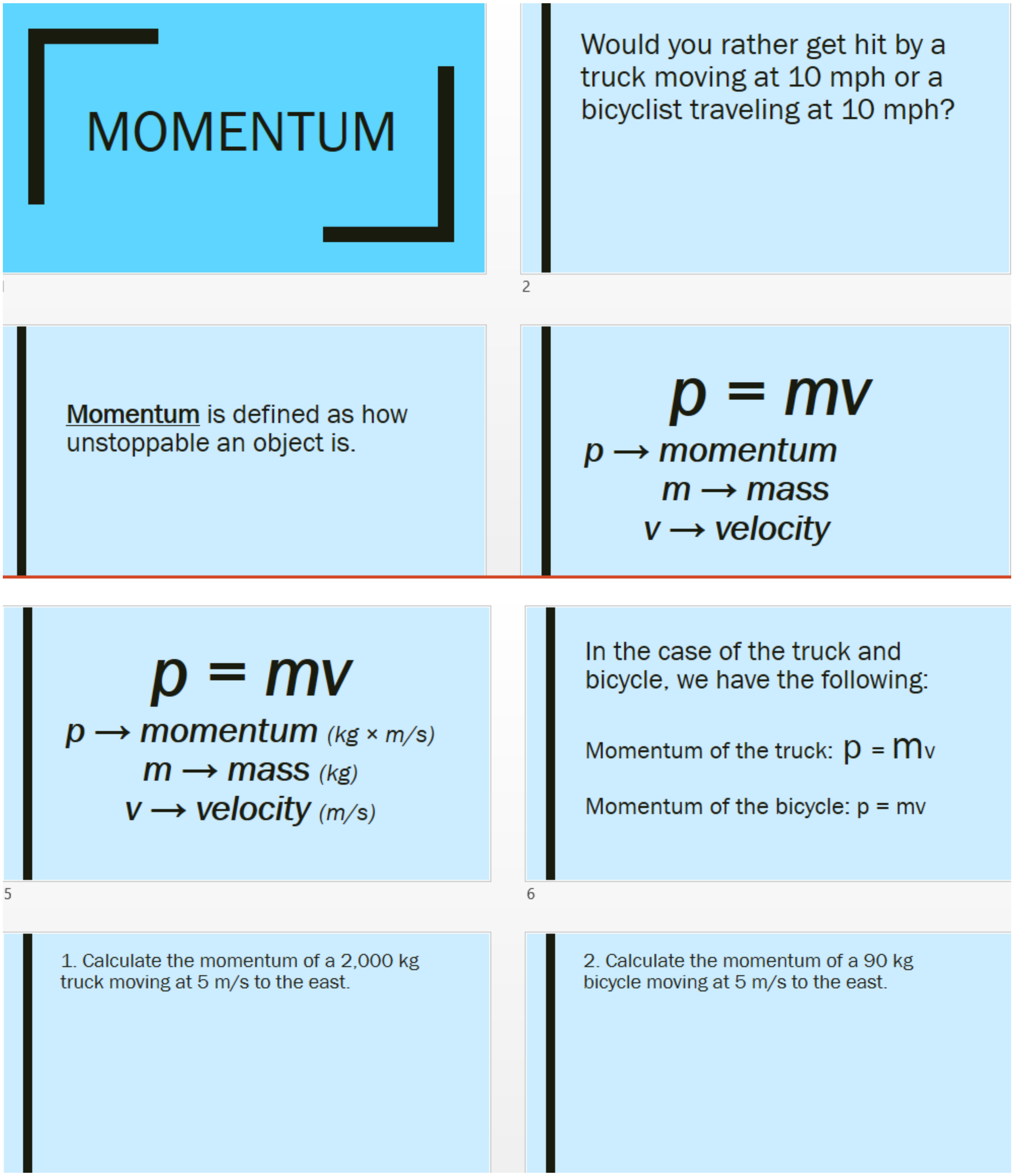
Instructional Delivery Methods
☒ Teacher Modeling/Demonstration
☐ Cooperative Learning
☐ Independent Projects
☒ Lecture
☐ Centers
☒ Discussion
☒ Problem Solving

Homework/Extension Activities:
Students are instructed to write one question they think might be seen on friday's quiz based on what they learned in class on an index card. The question can be a definition, calculation or, concept question.

Materials and Equipment Needed:
- Calculators
- Worksheet
- Index cards

Adapted from Grant Wiggins and Jay McTighe-*Understanding by Design*

PowerPoint



MOMENTUM

Would you rather get hit by a truck moving at 10 mph or a bicyclist traveling at 10 mph?

Momentum is defined as how unstoppable an object is.

$$p = mv$$

$p \rightarrow$ *momentum*

$m \rightarrow$ *mass*

$v \rightarrow$ *velocity*

$$p = mv$$

$p \rightarrow$ *momentum* (kg × m/s)

$m \rightarrow$ *mass* (kg)

$v \rightarrow$ *velocity* (m/s)

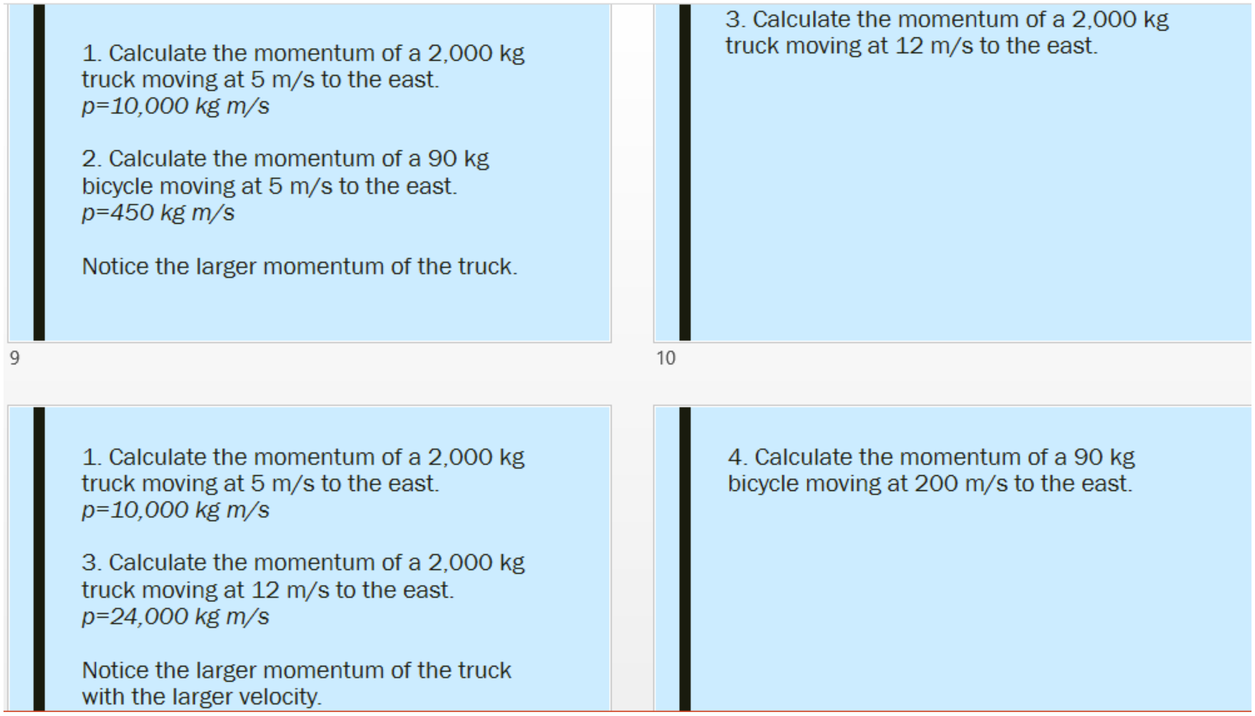
In the case of the truck and bicycle, we have the following:

Momentum of the truck: $p = mv$

Momentum of the bicycle: $p = mv$

1. Calculate the momentum of a 2,000 kg truck moving at 5 m/s to the east.

2. Calculate the momentum of a 90 kg bicycle moving at 5 m/s to the east.



1. Calculate the momentum of a 2,000 kg truck moving at 5 m/s to the east.
p=10,000 kg m/s

2. Calculate the momentum of a 90 kg bicycle moving at 5 m/s to the east.
p=450 kg m/s

Notice the larger momentum of the truck.

3. Calculate the momentum of a 2,000 kg truck moving at 12 m/s to the east.

1. Calculate the momentum of a 2,000 kg truck moving at 5 m/s to the east.
p=10,000 kg m/s

3. Calculate the momentum of a 2,000 kg truck moving at 12 m/s to the east.
p=24,000 kg m/s

Notice the larger momentum of the truck with the larger velocity.

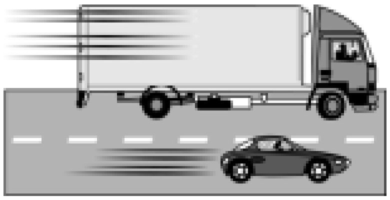
4. Calculate the momentum of a 90 kg bicycle moving at 200 m/s to the east.

Name: ______________________ Date: ______________

PRACTICE 3.1

Momentum

READ



Which is more difficult to stop: A tractor-trailer truck barreling down the highway at 35 meters per second, or a small two-seater sports car traveling the same speed?

You probably guessed that it takes more force to stop a large truck than a small car. In physics terms, we say that the truck has greater *momentum*.

We can find momentum using this equation:

$$\text{momentum} = \text{mass of object} \times \text{velocity of object}$$

Velocity is a term that refers to both speed and direction. For our purposes we will assume that the vehicles are traveling in a straight line. In that case, velocity and speed are the same.

The equation for momentum is abbreviated like this: $p = m \times v$.

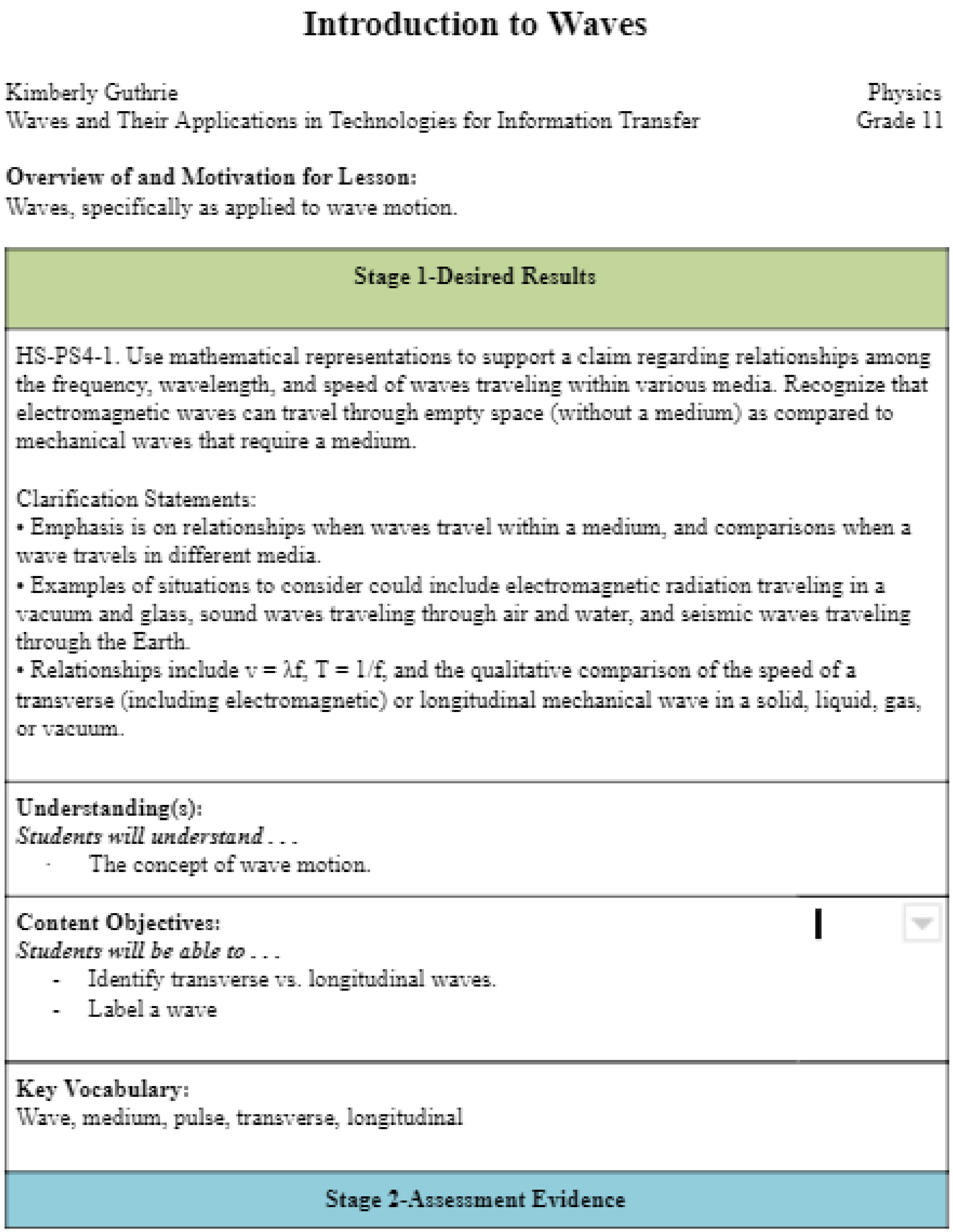
Momentum, symbolized with a p, is expressed in units of kg·m/sec; m is the mass of the object, in kilograms; and v is the velocity of the object in m/sec.

PRACTICE

Use your knowledge about solving equations to work out the following problems:

1. If the truck has a mass of 2,000 kilograms, what is its momentum? Express your answer in kg·m/sec.
2. If the car has a mass of 1,000 kilograms, what is its momentum?
3. An 8-kilogram bowling ball is rolling in a straight line toward you. If its momentum is 16 kg·m/sec, how fast is it traveling?
4. A beach ball is rolling in a straight line toward you at a speed of 0.5 m/sec. Its momentum is 0.25 kg·m/sec. What is the mass of the beach ball?
5. A 4,000-kilogram truck travels in a straight line at 10.0 m/sec. What is its momentum?
6. A 1,400-kilogram car is also traveling in a straight line. Its momentum is equal to that of the truck in the previous question. What is the velocity of the car?
7. Which would take more force to stop in 10 seconds: an 8.0-kilogram ball rolling in a straight line at a speed of 0.2 m/sec or a 4.0-kilogram ball rolling along the same path at a speed of 1.0 m/sec?
8. The momentum of a car traveling in a straight line at 20 m/sec is 24,500 kg·m/sec. What is the car's mass?
9. A 0.14-kilogram baseball is thrown in a straight line at a velocity of 30 m/sec. What is the momentum of the baseball?
10. Another pitcher throws the same baseball in a straight line. Its momentum is 2.1 kg·m/sec. What is the velocity of the ball?
11. A 1-kilogram turtle crawls in a straight line at a speed of 0.01 m/sec. What is the turtle's momentum?

Appendix C: Week 6 Day 1 Lesson Plan Page 1 of 7



Introduction to Waves

Kimberly Guthrie Physics
Waves and Their Applications in Technologies for Information Transfer Grade 11

Overview of and Motivation for Lesson:
Waves, specifically as applied to wave motion.

Stage 1-Desired Results

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.

Clarification Statements:
• Emphasis is on relationships when waves travel within a medium, and comparisons when a wave travels in different media.
• Examples of situations to consider could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.
• Relationships include $v = \lambda f$, $T = 1/f$, and the qualitative comparison of the speed of a transverse (including electromagnetic) or longitudinal mechanical wave in a solid, liquid, gas, or vacuum.

Understanding(s):
Students will understand . . .

- The concept of wave motion.

Content Objectives:
Students will be able to . . .

- Identify transverse vs. longitudinal waves.
- Label a wave

Key Vocabulary:
Wave, medium, pulse, transverse, longitudinal

Stage 2-Assessment Evidence

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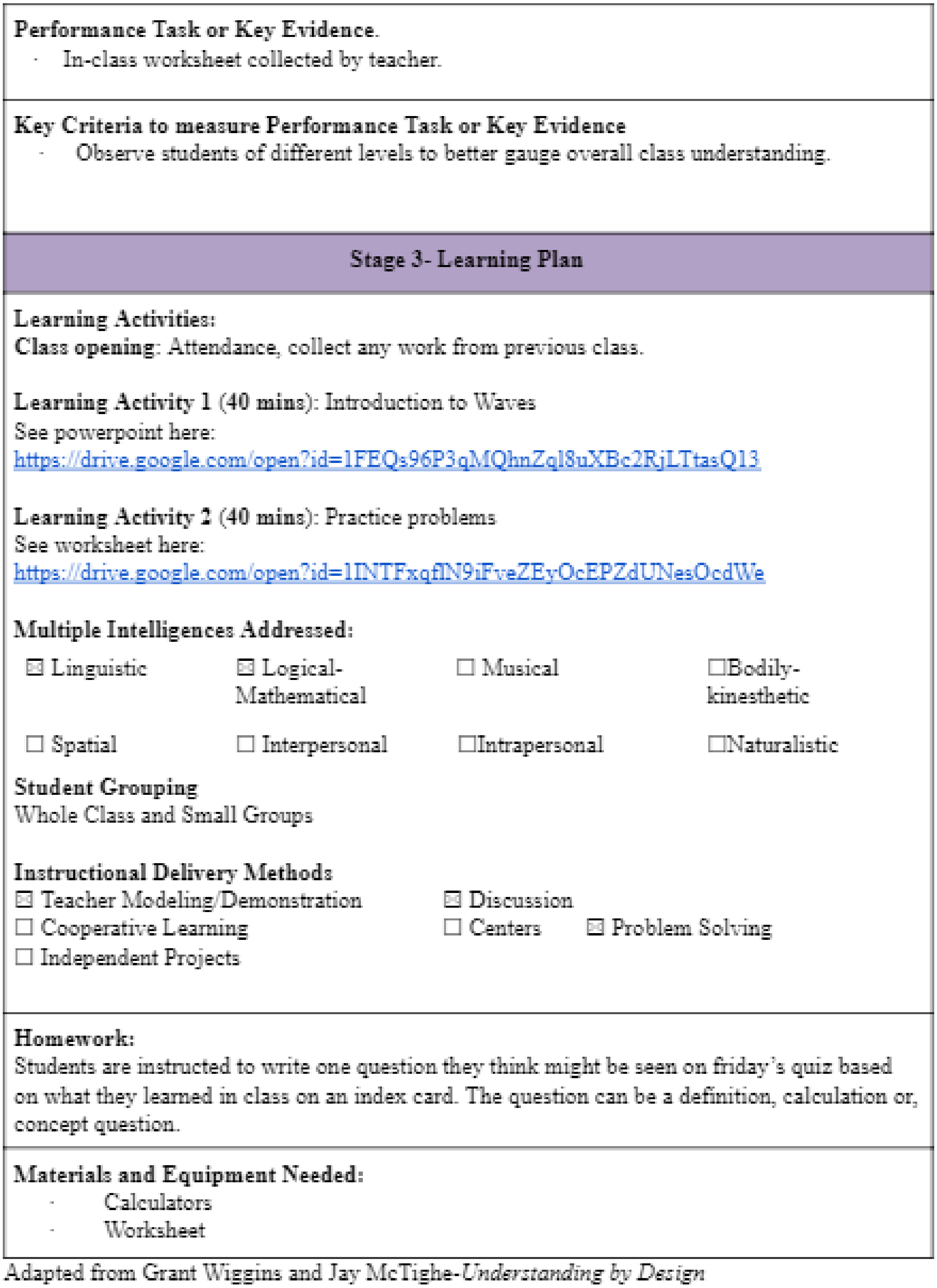


Performance Task or Key Evidence.

- In-class worksheet collected by teacher.

Key Criteria to measure Performance Task or Key Evidence

- Observe students of different levels to better gauge overall class understanding.

Stage 3- Learning Plan

Learning Activities:
Class opening: Attendance, collect any work from previous class.

Learning Activity 1 (**40 mins**): Introduction to Waves
See powerpoint here:
https://drive.google.com/open?id=1FEQs96P3qMQhnZql8uXBc2RjLTtasQ13

Learning Activity 2 (**40 mins**): Practice problems
See worksheet here:
https://drive.google.com/open?id=1INTFxqfIN9iFveZEyOcEPZdUNesOcdWe

Multiple Intelligences Addressed:

☒ Linguistic
☒ Logical-Mathematical
☐ Musical
☐Bodily-kinesthetic
☐ Spatial
☐ Interpersonal
☐Intrapersonal
☐Naturalistic

Student Grouping
Whole Class and Small Groups

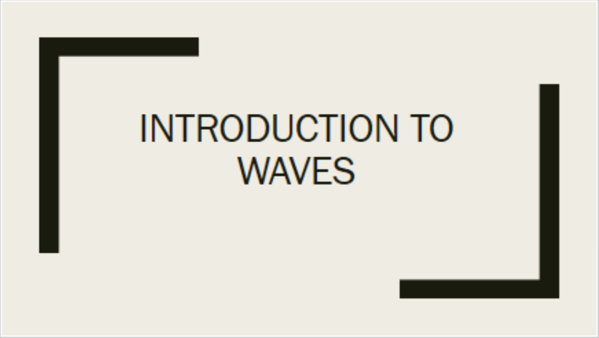
Instructional Delivery Methods
☒ Teacher Modeling/Demonstration
☒ Discussion
☐ Cooperative Learning
☐ Centers
☒ Problem Solving
☐ Independent Projects

Homework:
Students are instructed to write one question they think might be seen on friday's quiz based on what they learned in class on an index card. The question can be a definition, calculation or, concept question.

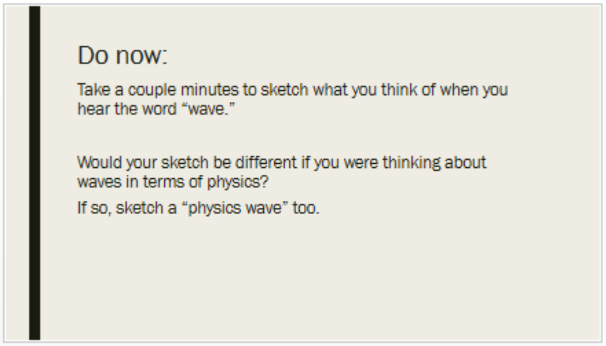
Materials and Equipment Needed:

- Calculators
- Worksheet

Adapted from Grant Wiggins and Jay McTighe-*Understanding by Design*



INTRODUCTION TO WAVES

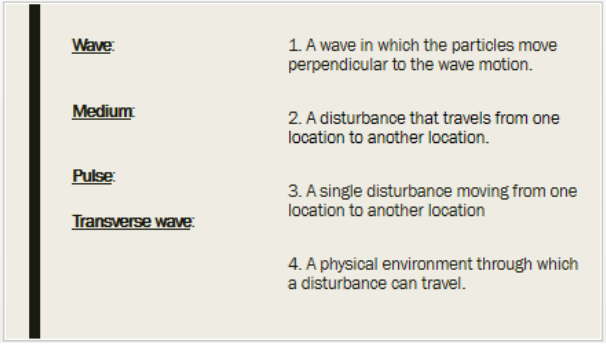


Do now:

Take a couple minutes to sketch what you think of when you hear the word "wave."

Would your sketch be different if you were thinking about waves in terms of physics?

If so, sketch a "physics wave" too.



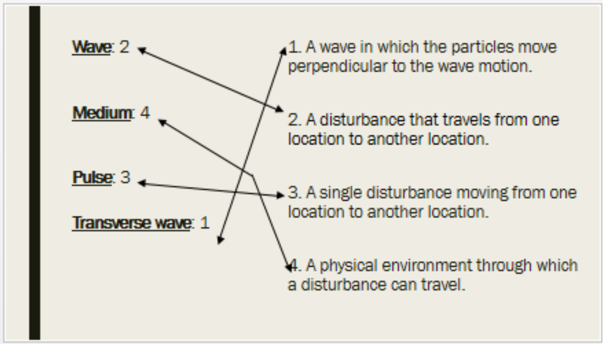
Wave:

Medium:

Pulse:

Transverse wave:

1. A wave in which the particles move perpendicular to the wave motion.
2. A disturbance that travels from one location to another location.
3. A single disturbance moving from one location to another location
4. A physical environment through which a disturbance can travel.



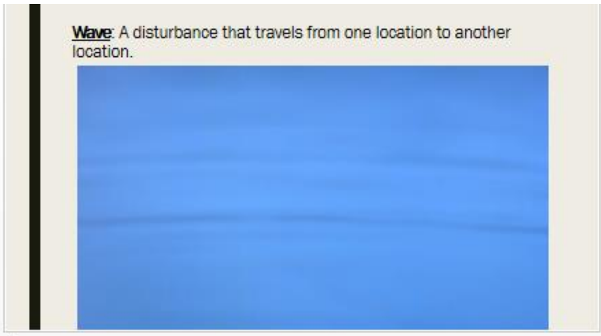
Wave: 2

Medium: 4

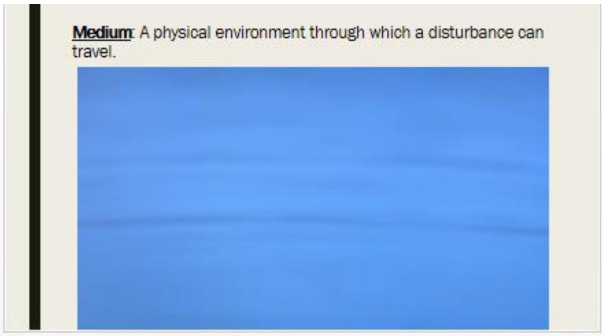
Pulse: 3

Transverse wave: 1

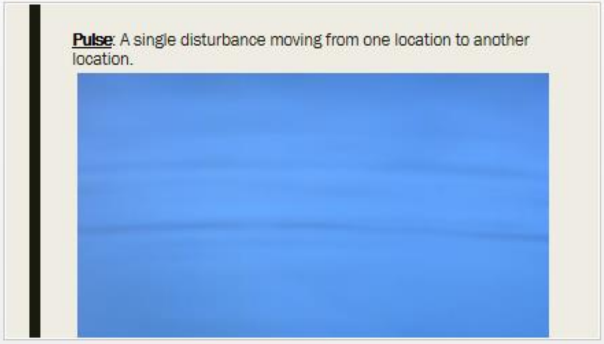
1. A wave in which the particles move perpendicular to the wave motion.
2. A disturbance that travels from one location to another location.
3. A single disturbance moving from one location to another location.
4. A physical environment through which a disturbance can travel.



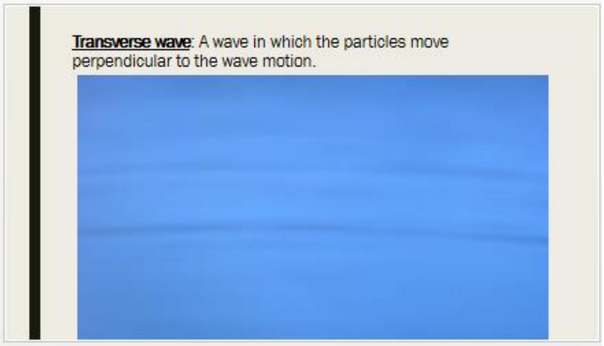
Wave: A disturbance that travels from one location to another location.



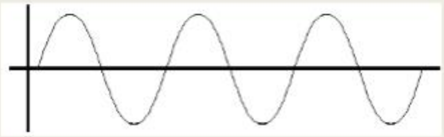
Medium: A physical environment through which a disturbance can travel.



Pulse: A single disturbance moving from one location to another location.



Transverse wave: A wave in which the particles move perpendicular to the wave motion.



Crest, Trough, Amplitude, and Wavelength

Two types of waves:

Transverse wave: A wave in which the particles move perpendicular to the wave motion.

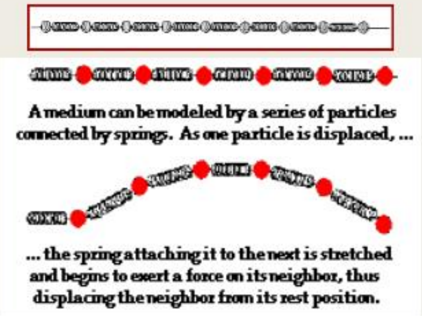
Longitudinal wave: A wave in which the particles move parallel to the wave motion.

Two types of waves:

Transverse wave: A wave in which the particles move perpendicular to the wave motion.

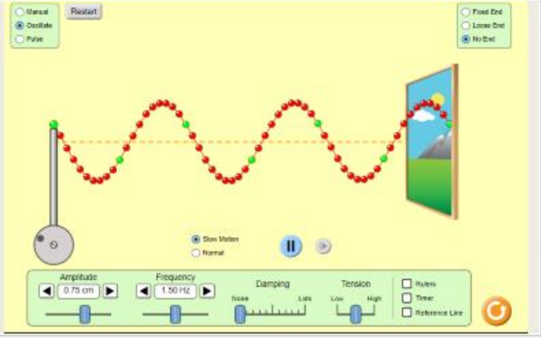
Longitudinal wave: A wave in which the particles move parallel to the wave motion.

Waves **only transfer energy**, not particles.



A medium can be modeled by a series of particles connected by springs. As one particle is displaced, ...

... the spring attaching it to the next is stretched and begins to exert a force on its neighbor, thus displacing the neighbor from its rest position.



○ Manual
● Oscillate
○ Pulse

○ Fixed End
○ Loose End
● No End

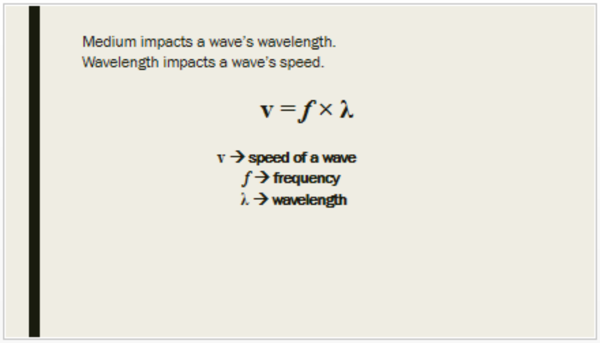
● Slow Motion
○ Normal

Amplitude 0.75 cm

Frequency 1.50 Hz

Medium impacts a wave's wavelength.

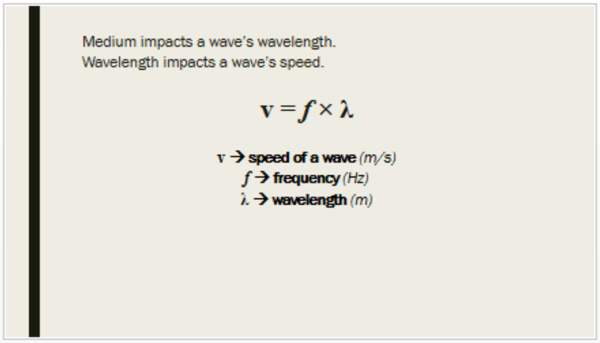
Medium impacts a wave's wavelength.
Wavelength impacts a wave's speed.



Medium impacts a wave's wavelength.
Wavelength impacts a wave's speed.

$$v = f \times \lambda$$

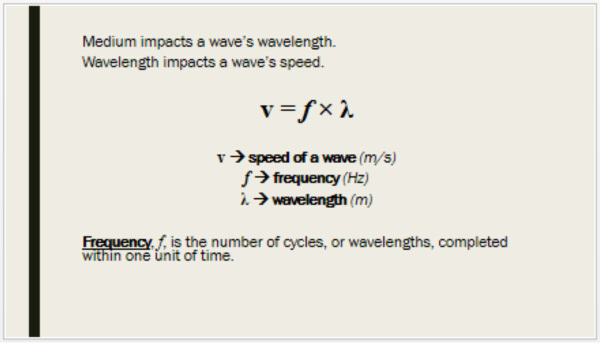
v → **speed of a wave**
f → **frequency**
λ → **wavelength**



Medium impacts a wave's wavelength.
Wavelength impacts a wave's speed.

$$v = f \times \lambda$$

v → **speed of a wave** *(m/s)*
f → **frequency** *(Hz)*
λ → **wavelength** *(m)*

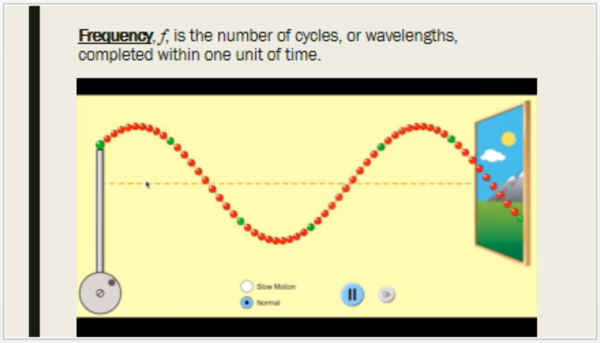


Medium impacts a wave's wavelength.
Wavelength impacts a wave's speed.

$$v = f \times \lambda$$

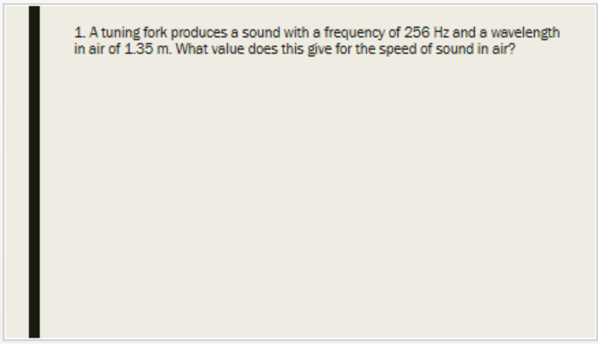
v → **speed of a wave** *(m/s)*
f → **frequency** *(Hz)*
λ → **wavelength** *(m)*

Frequency, *f*, is the number of cycles, or wavelengths, completed within one unit of time.

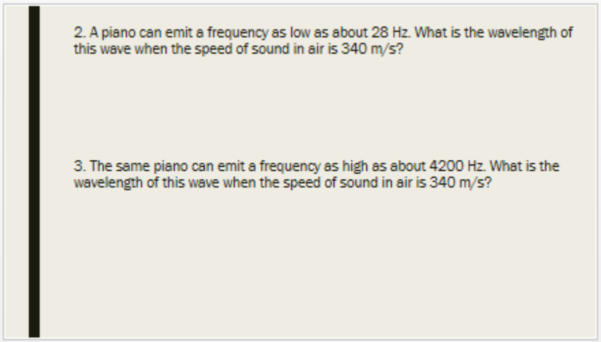


Frequency, *f*, is the number of cycles, or wavelengths, completed within one unit of time.

○ Slow Motion
● Normal



1. A tuning fork produces a sound with a frequency of 256 Hz and a wavelength in air of 1.35 m. What value does this give for the speed of sound in air?



2. A piano can emit a frequency as low as about 28 Hz. What is the wavelength of this wave when the speed of sound in air is 340 m/s?

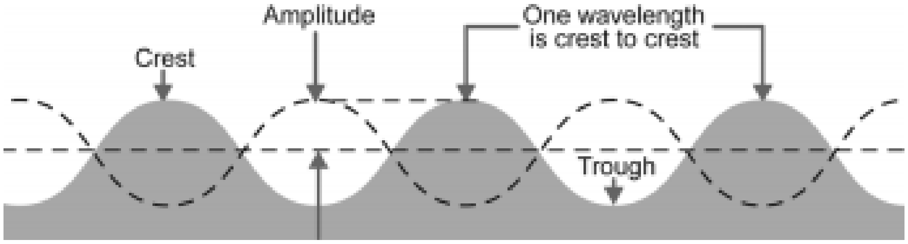
3. The same piano can emit a frequency as high as about 4200 Hz. What is the wavelength of this wave when the speed of sound in air is 340 m/s?

Name: ______________________________ Date: ______________

Waves

READ

A **wave** is a traveling oscillator that carries energy from one place to another. A high point of a wave is called a **crest**. A low point is called a **trough**. The amplitude of a wave is half the distance from a crest to a trough. The distance from one crest to the next is called the **wavelength**. Wavelength can also be measured from trough to trough or from any point on the wave to the next place where that point occurs.



The speed of a wave

Frequency (hertz)

Speed (m/sec) → $v = f\lambda$ ← Wavelength (meters)

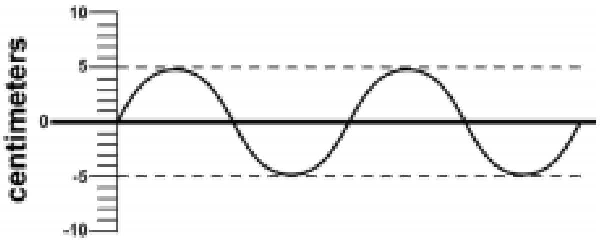
EXAMPLE

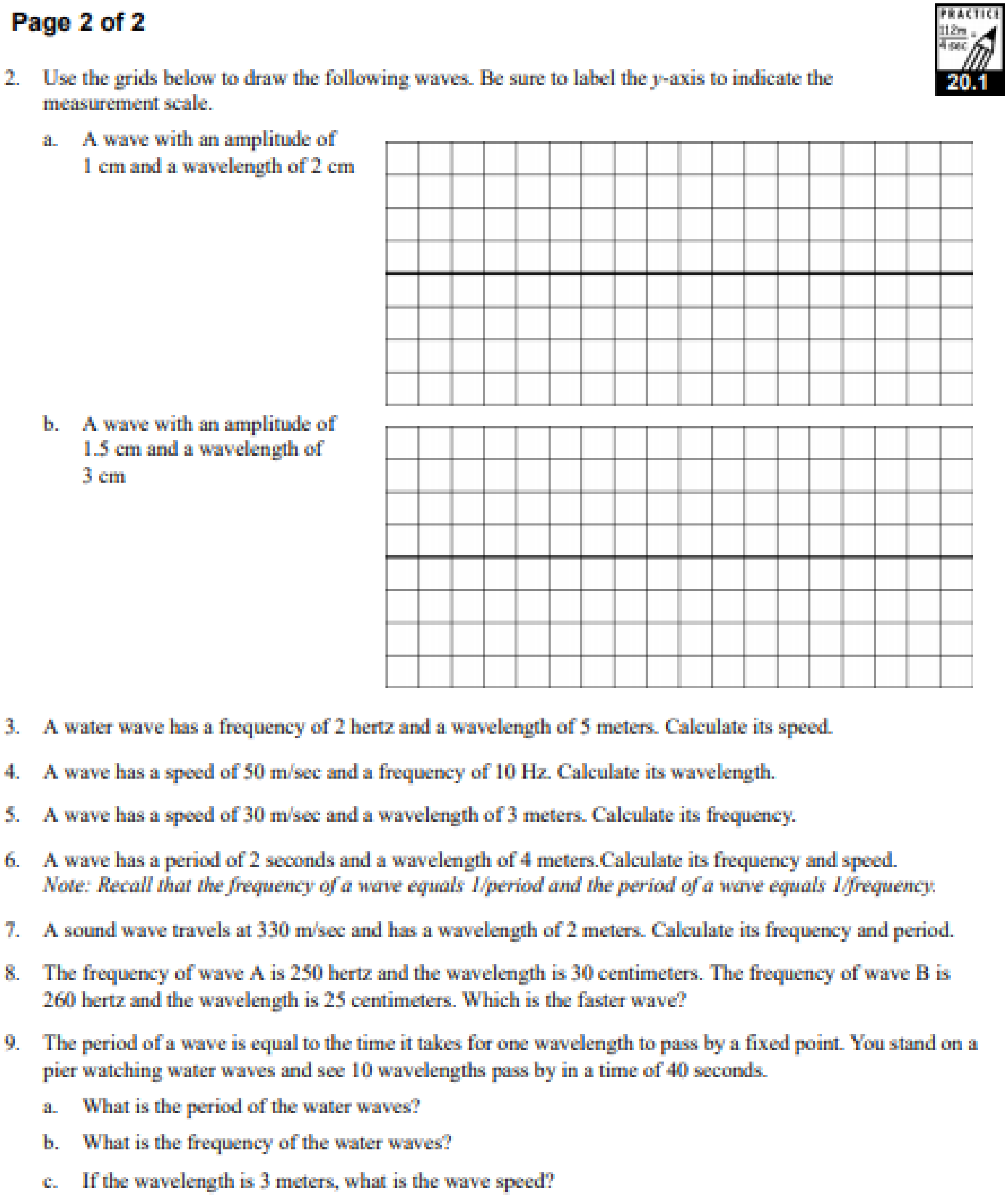
The frequency of a wave is 40 Hz and its speed is 100 meters per second. What is the wavelength of this wave?

Given Frequency = 40 Hz; Speed = 100 m/sec	**Solution** $\frac{100 \text{ m/sec}}{40 \text{ Hz}} = \frac{100 \text{ m/sec}}{40 \text{ cycles/sec}} = \text{Wavelength}$ 2.5 meters = Wavelength The wavelength of this wave is 2.5 meters.
Looking for The wavelength	
Relationships Speed = Frequency × Wavelength, therefore Speed + Frequency = Wavelength	

PRACTICE

1. On the graphic at right label the following parts of a wave: one wavelength, half of a wavelength, the amplitude, a crest, and a trough.
    a. How many wavelengths are represented in the wave above?
    b. What is the amplitude of the wave shown above?





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20.1

2. Use the grids below to draw the following waves. Be sure to label the y-axis to indicate the measurement scale.
   a. A wave with an amplitude of 1 cm and a wavelength of 2 cm
   b. A wave with an amplitude of 1.5 cm and a wavelength of 3 cm

3. A water wave has a frequency of 2 hertz and a wavelength of 5 meters. Calculate its speed.

4. A wave has a speed of 50 m/sec and a frequency of 10 Hz. Calculate its wavelength.

5. A wave has a speed of 30 m/sec and a wavelength of 3 meters. Calculate its frequency.

6. A wave has a period of 2 seconds and a wavelength of 4 meters.Calculate its frequency and speed. *Note: Recall that the frequency of a wave equals 1/period and the period of a wave equals 1/frequency.*

7. A sound wave travels at 330 m/sec and has a wavelength of 2 meters. Calculate its frequency and period.

8. The frequency of wave A is 250 hertz and the wavelength is 30 centimeters. The frequency of wave B is 260 hertz and the wavelength is 25 centimeters. Which is the faster wave?

9. The period of a wave is equal to the time it takes for one wavelength to pass by a fixed point. You stand on a pier watching water waves and see 10 wavelengths pass by in a time of 40 seconds.
   a. What is the period of the water waves?
   b. What is the frequency of the water waves?
   c. If the wavelength is 3 meters, what is the wave speed?

Appendix D: Week 13 Day 1 Lesson Plan

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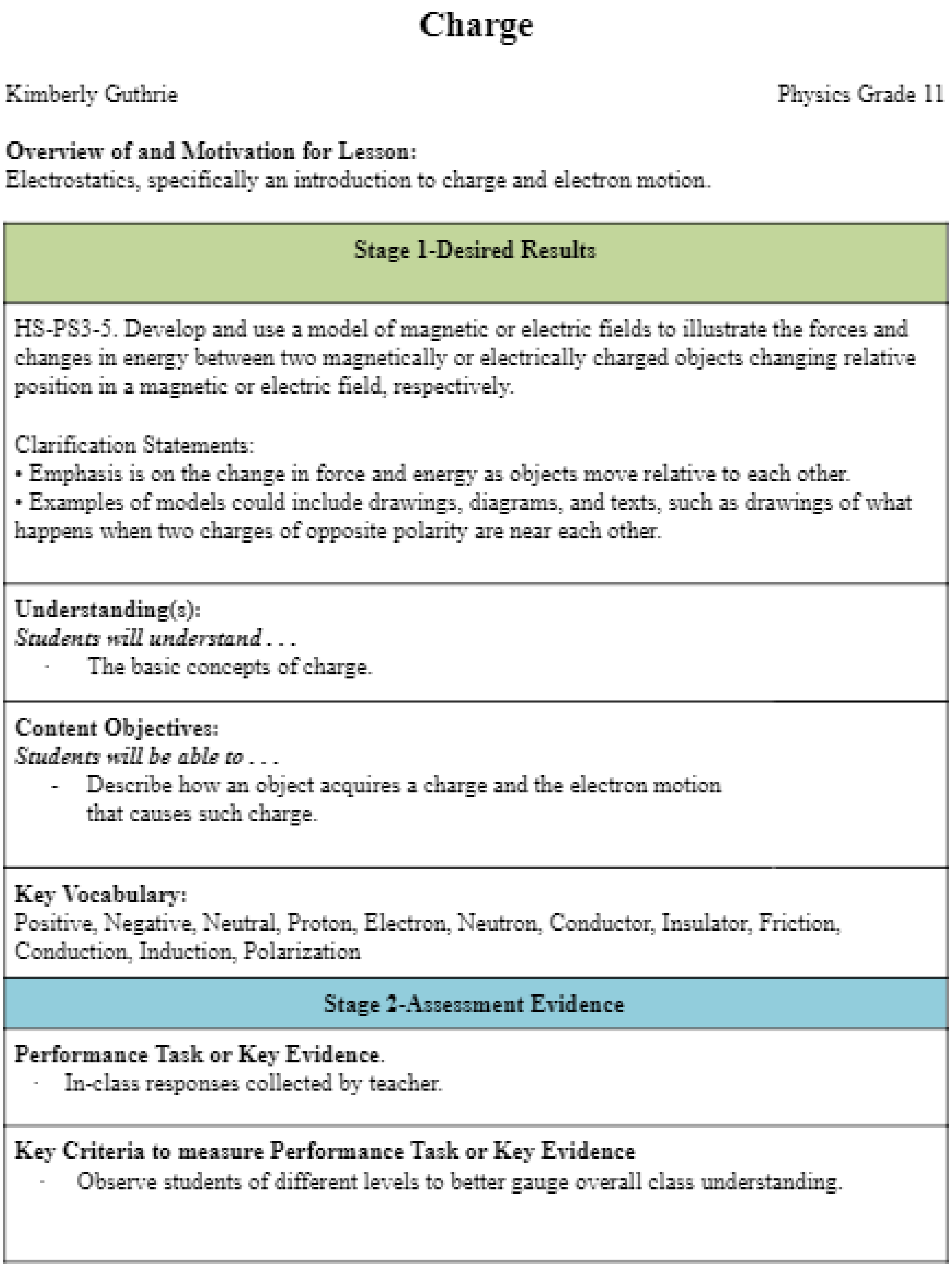

Charge

Kimberly Guthrie

Physics Grade 11

Overview of and Motivation for Lesson:
Electrostatics, specifically an introduction to charge and electron motion.

Stage 1-Desired Results

HS-PS3-5. Develop and use a model of magnetic or electric fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a magnetic or electric field, respectively.

Clarification Statements:
• Emphasis is on the change in force and energy as objects move relative to each other.
• Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

Understanding(s):
Students will understand . . .

- The basic concepts of charge.

Content Objectives:
Students will be able to . . .

- Describe how an object acquires a charge and the electron motion that causes such charge.

Key Vocabulary:
Positive, Negative, Neutral, Proton, Electron, Neutron, Conductor, Insulator, Friction, Conduction, Induction, Polarization

Stage 2-Assessment Evidence

Performance Task or Key Evidence.

- In-class responses collected by teacher.

Key Criteria to measure Performance Task or Key Evidence

- Observe students of different levels to better gauge overall class understanding.

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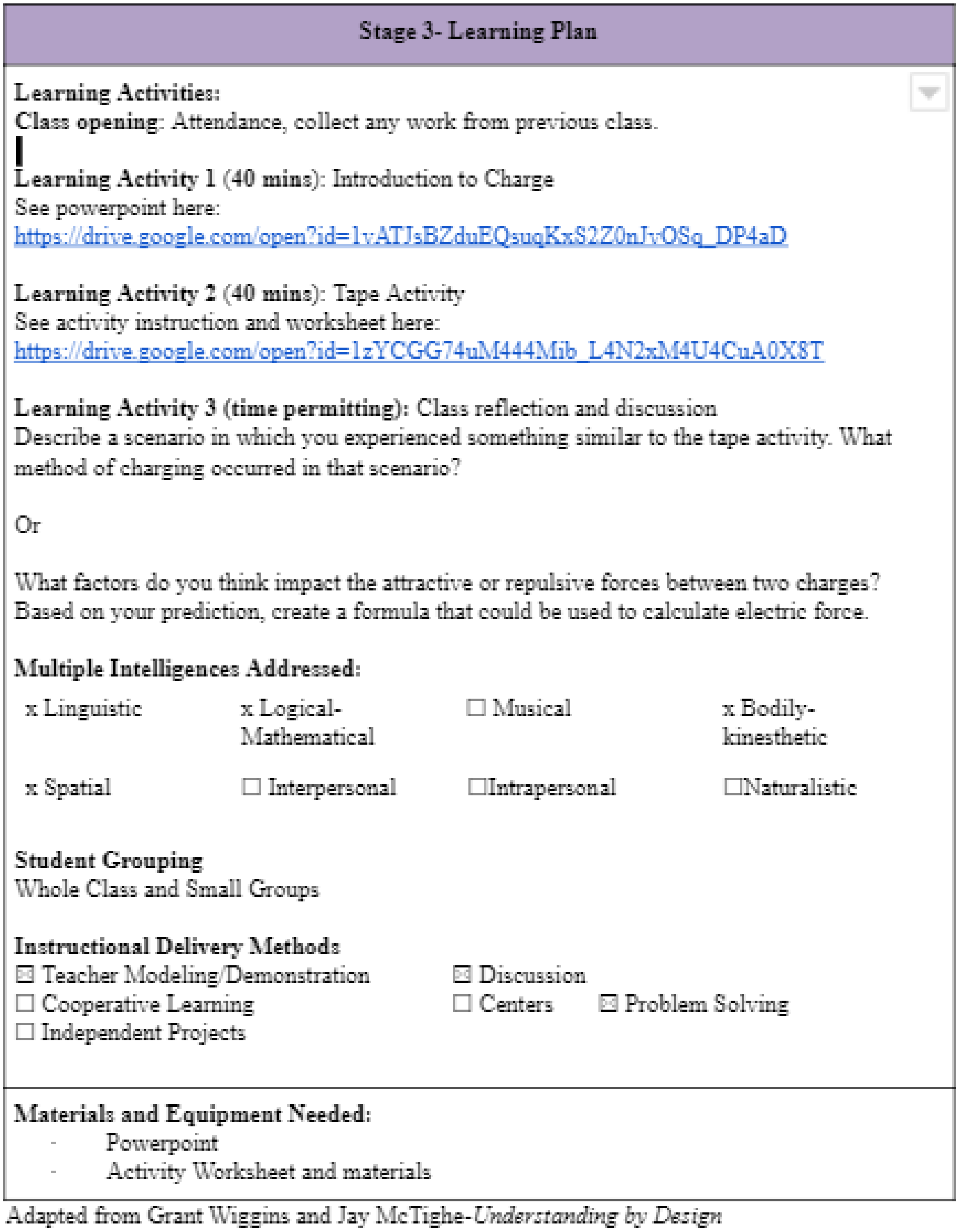


Stage 3- Learning Plan

Learning Activities:
Class opening: Attendance, collect any work from previous class.

Learning Activity 1 (40 mins): Introduction to Charge
See powerpoint here:
https://drive.google.com/open?id=1vATJsBZduEQsuqKxS2Z0nJvOSq_DP4aD

Learning Activity 2 (40 mins): Tape Activity
See activity instruction and worksheet here:
https://drive.google.com/open?id=1zYCGG74uM444Mib_L4N2xM4U4CuA0X8T

Learning Activity 3 (time permitting): Class reflection and discussion
Describe a scenario in which you experienced something similar to the tape activity. What method of charging occurred in that scenario?

Or

What factors do you think impact the attractive or repulsive forces between two charges? Based on your prediction, create a formula that could be used to calculate electric force.

Multiple Intelligences Addressed:

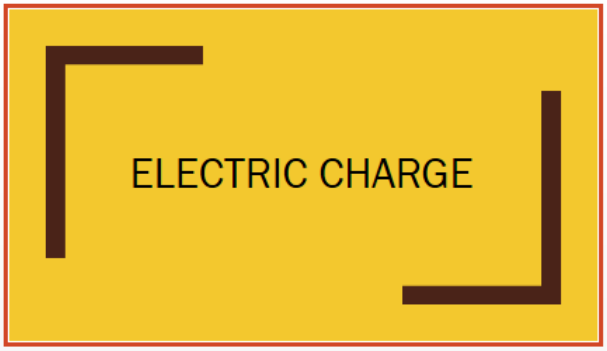
x Linguistic	x Logical-Mathematical	☐ Musical	x Bodily-kinesthetic
x Spatial	☐ Interpersonal	☐Intrapersonal	☐Naturalistic

Student Grouping
Whole Class and Small Groups

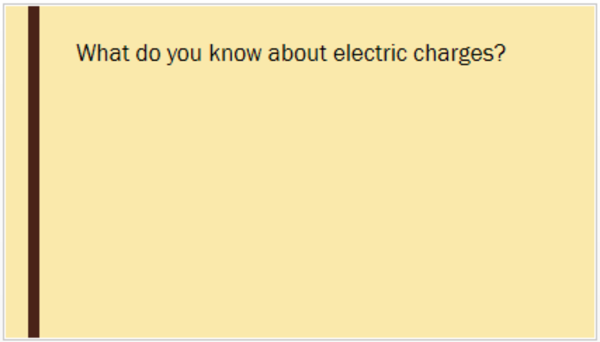
Instructional Delivery Methods
☒ Teacher Modeling/Demonstration
☐ Cooperative Learning
☐ Independent Projects
☒ Discussion
☐ Centers
☒ Problem Solving

Materials and Equipment Needed:
- Powerpoint
- Activity Worksheet and materials

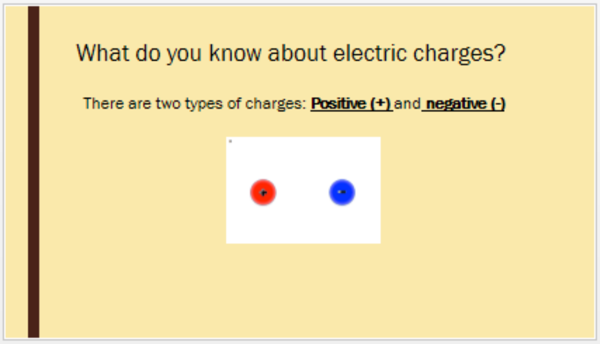
Adapted from Grant Wiggins and Jay McTighe-*Understanding by Design*



ELECTRIC CHARGE

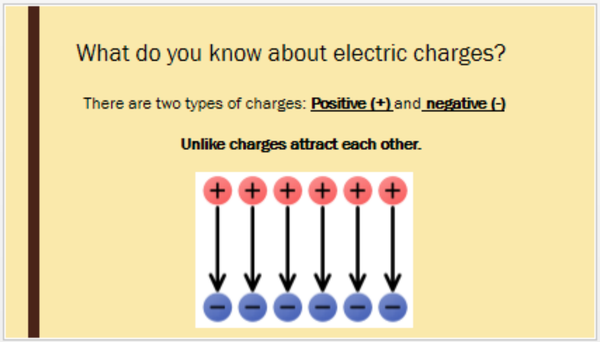


What do you know about electric charges?



What do you know about electric charges?

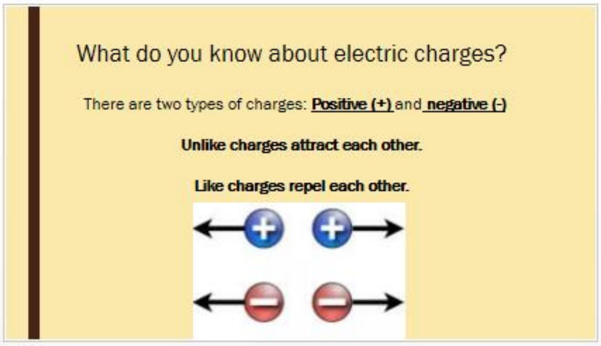
There are two types of charges: **Positive (+)** and **negative (-)**



What do you know about electric charges?

There are two types of charges: **Positive (+)** and **negative (-)**

Unlike charges attract each other.

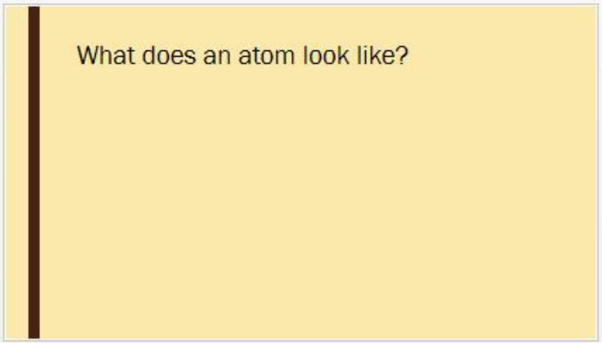


What do you know about electric charges?

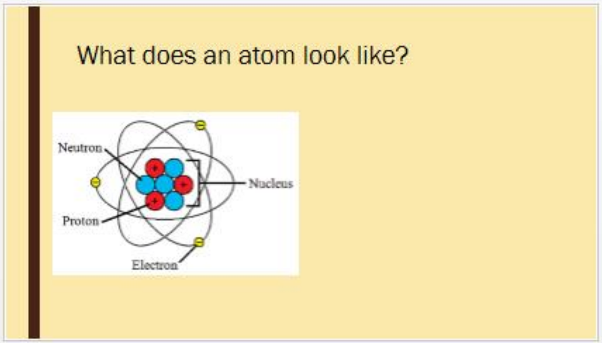
There are two types of charges: **Positive (+)** and **negative (-)**

Unlike charges attract each other.

Like charges repel each other.



What does an atom look like?



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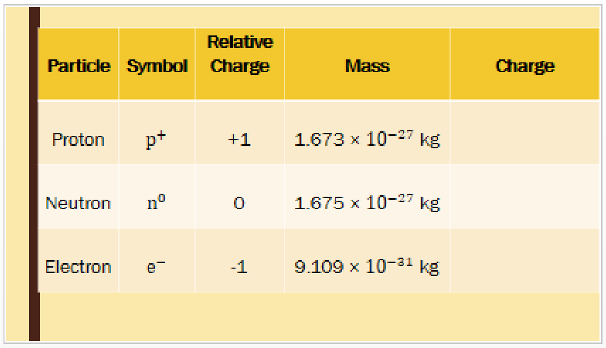
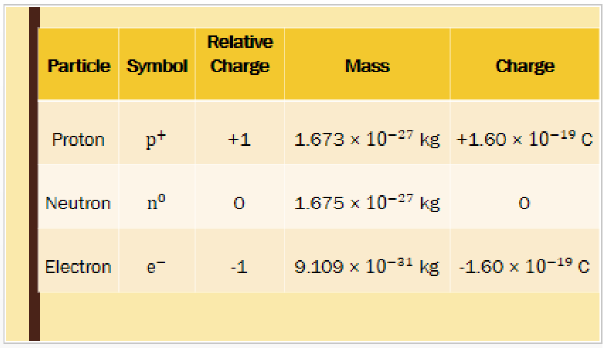
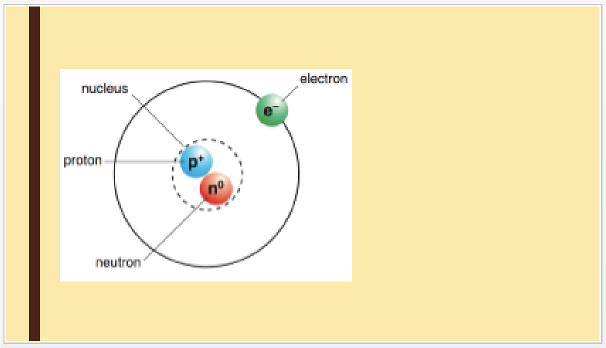
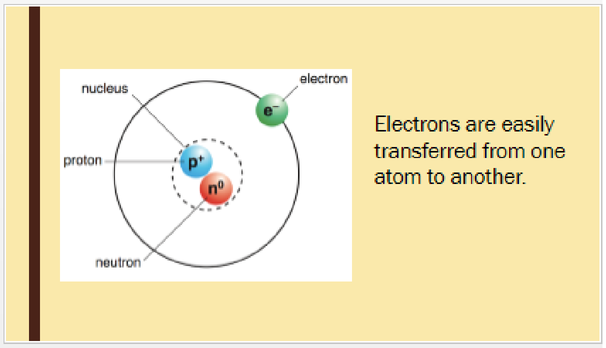


Particle	Symbol	Relative Charge	Mass	Charge
Proton	p^+	+1	1.673×10^{-27} kg	
Neutron	n^0	0	1.675×10^{-27} kg	
Electron	e^-	-1	9.109×10^{-31} kg	

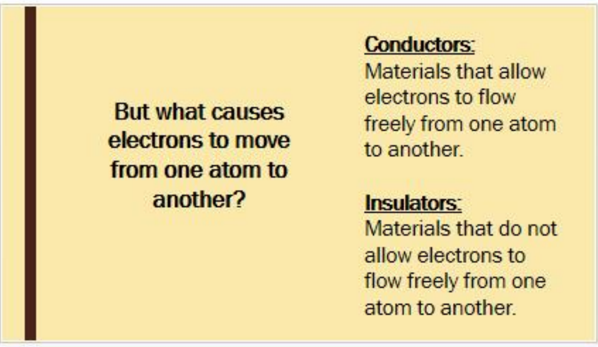


Particle	Symbol	Relative Charge	Mass	Charge
Proton	p^+	+1	1.673×10^{-27} kg	$+1.60 \times 10^{-19}$ C
Neutron	n^0	0	1.675×10^{-27} kg	0
Electron	e^-	-1	9.109×10^{-31} kg	-1.60×10^{-19} C





Electrons are easily transferred from one atom to another.

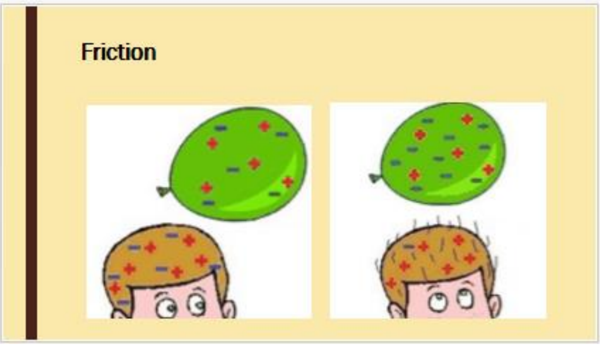


But what causes electrons to move from one atom to another?

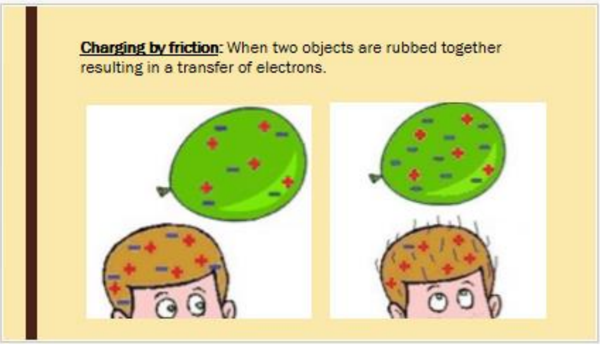
Conductors:
Materials that allow electrons to flow freely from one atom to another.

Insulators:
Materials that do not allow electrons to flow freely from one atom to another.

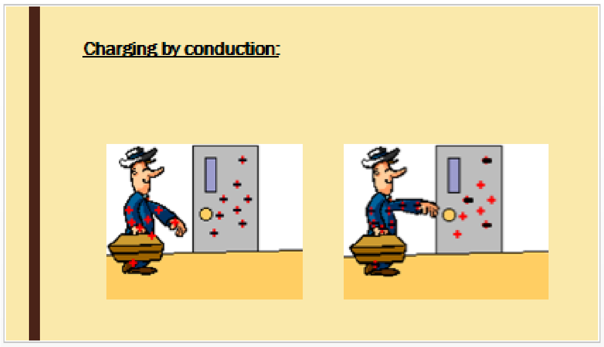
Friction



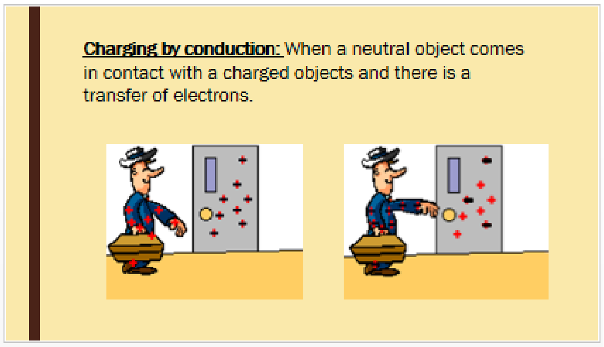
Friction



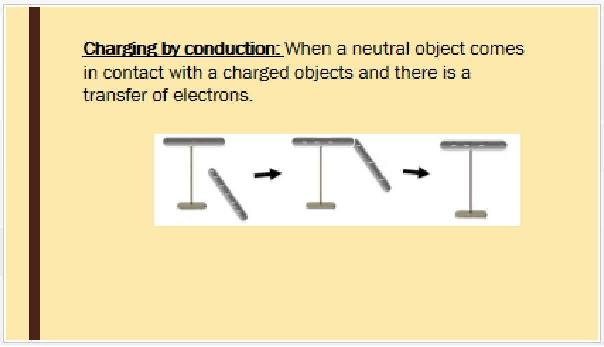
Charging by friction: When two objects are rubbed together resulting in a transfer of electrons.



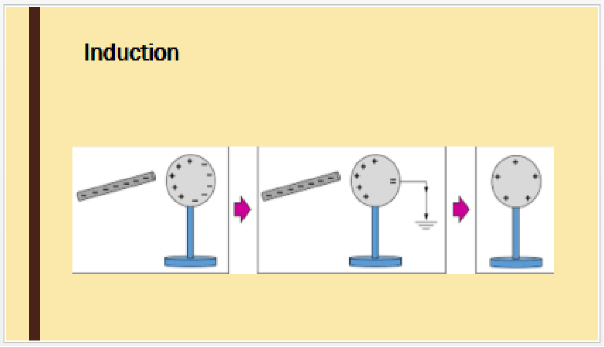
Charging by conduction:



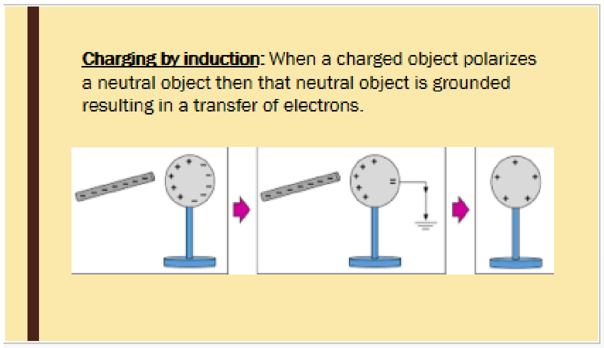
Charging by conduction: When a neutral object comes in contact with a charged objects and there is a transfer of electrons.



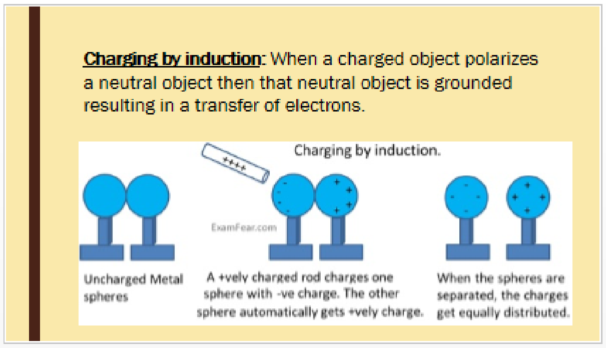
Charging by conduction: When a neutral object comes in contact with a charged objects and there is a transfer of electrons.



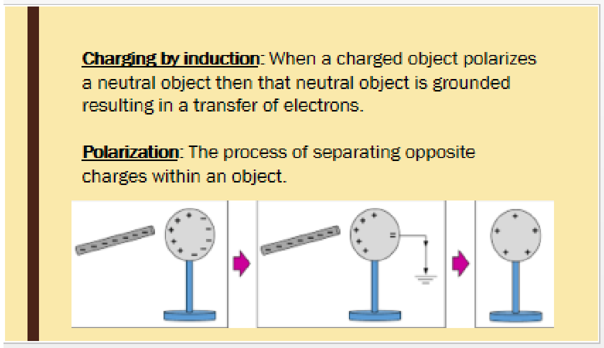
Induction



Charging by induction: When a charged object polarizes a neutral object then that neutral object is grounded resulting in a transfer of electrons.

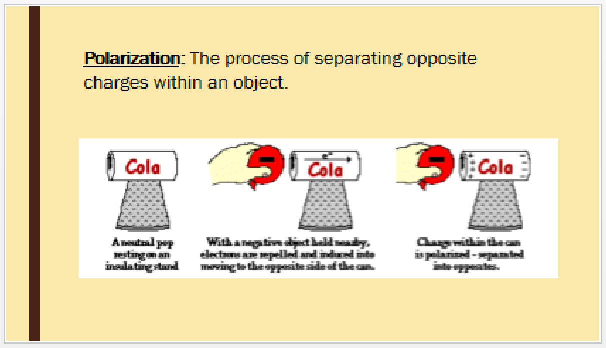


Charging by induction: When a charged object polarizes a neutral object then that neutral object is grounded resulting in a transfer of electrons.



Charging by induction: When a charged object polarizes a neutral object then that neutral object is grounded resulting in a transfer of electrons.

Polarization: The process of separating opposite charges within an object.



Polarization: The process of separating opposite charges within an object.

Charging Sticky Tape

Instructions:

1. Take your long piece of transparent tape and break it into three even pieces.

2. Stick one piece flat to the table. This is your base tape.

3. Take another piece of transparent tape and make a handle on the end by folding under the first ½ -inch of tape, sticky side to sticky side. Place this tape on top of the base tape and label the handle "B" for bottom.

4. Attach a second similarly prepared strip of tape to the bottom tape. Label this tape "T" for top.

4. Peel both T and B tapes from the base tape, keeping the T and B tapes stuck together. If the T and B tapes separate gently stick them back together.

5. Once removed from table, hold the T and B tapes by their handles and quickly rip them apart.

6. If the pieces of tape are attracted to your hand, shake them loose while still holding on to the tape handles.

7. Slowly bring the separated T and B tapes closer together without letting them touch.

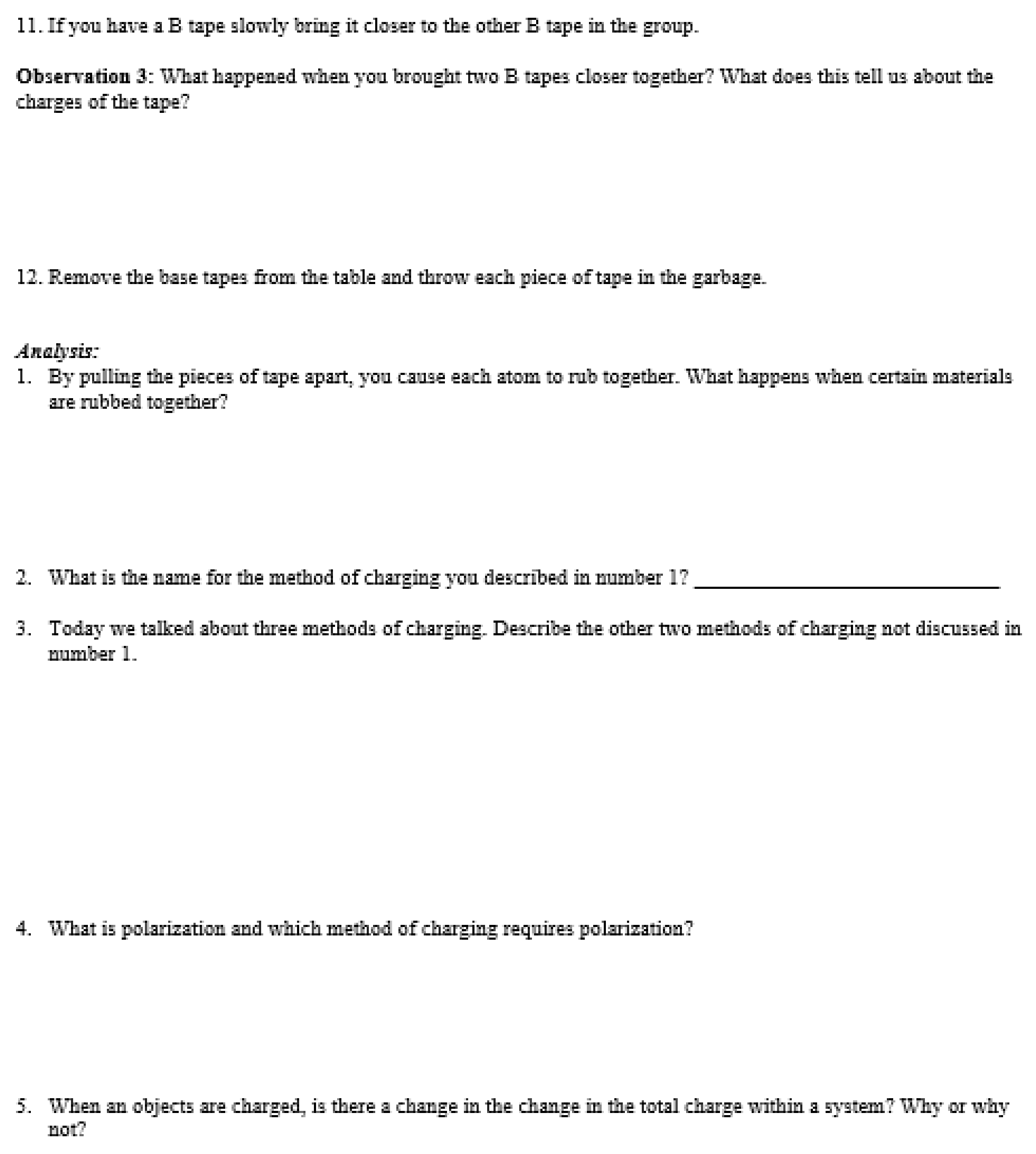
Observation 1: What happened when you brought T and B tapes closer together? What does this tell us about the charges of the tape?

8. Team up with another group.

9. Distribute the T and B tapes so each person has at least one piece.

10. If you have a T tape slowly bring it closer to the other T tape in the group.

Observation 2: What happened when you brought the two T tapes closer together? What does this tell us about the charges of the tape?



11. If you have a B tape slowly bring it closer to the other B tape in the group.

Observation 3: What happened when you brought two B tapes closer together? What does this tell us about the charges of the tape?

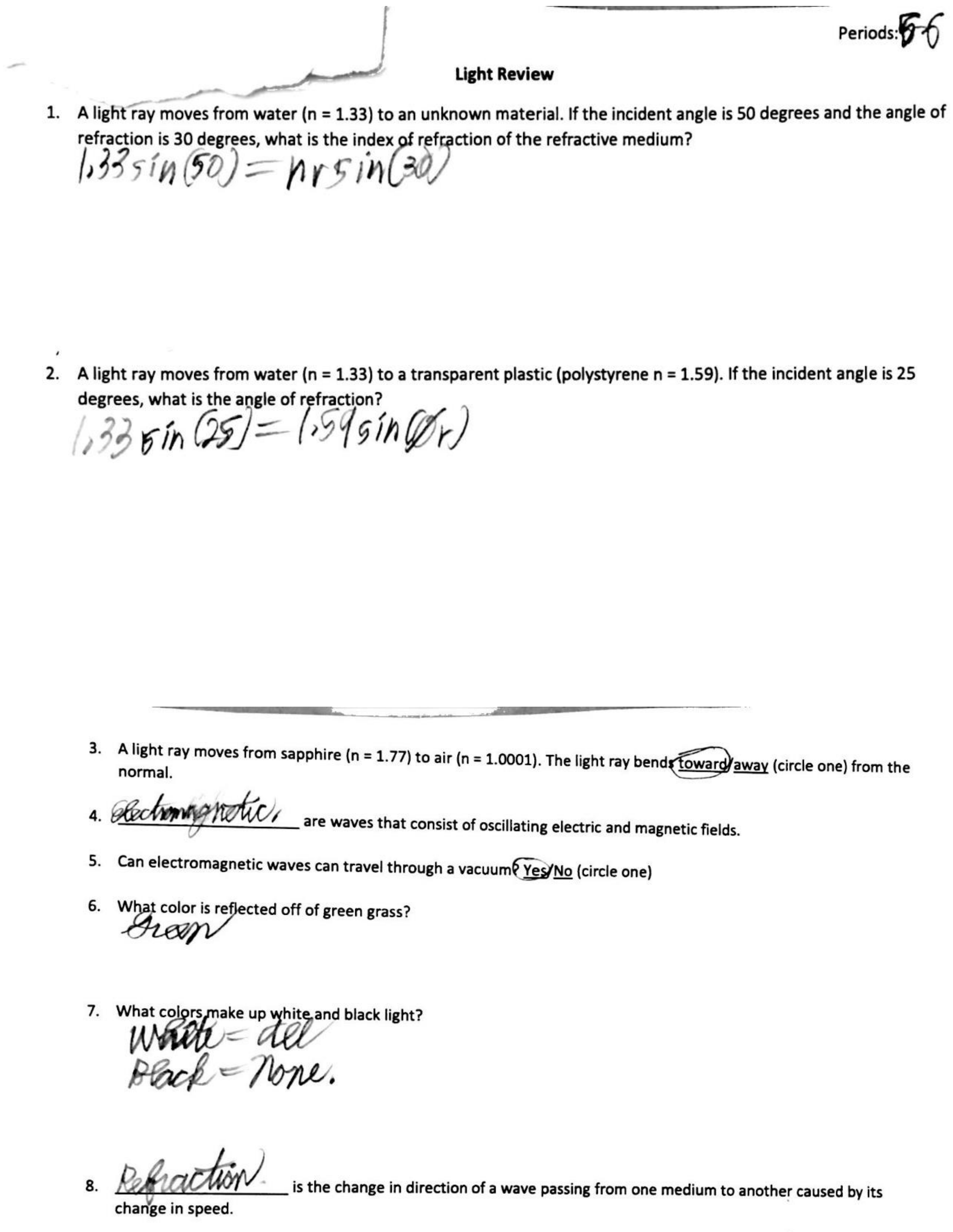
12. Remove the base tapes from the table and throw each piece of tape in the garbage.

Analysis:

1. By pulling the pieces of tape apart, you cause each atom to rub together. What happens when certain materials are rubbed together?
2. What is the name for the method of charging you described in number 1? ______________________________
3. Today we talked about three methods of charging. Describe the other two methods of charging not discussed in number 1.
4. What is polarization and which method of charging requires polarization?
5. When an objects are charged, is there a change in the change in the total charge within a system? Why or why not?

Appendix E: Student Work - Incomplete Homework

Page 1 of 1



Periods: 5-6

Light Review

1. A light ray moves from water (n = 1.33) to an unknown material. If the incident angle is 50 degrees and the angle of refraction is 30 degrees, what is the index of refraction of the refractive medium?

$1,33 \sin(50) = nr \sin(30)$

2. A light ray moves from water (n = 1.33) to a transparent plastic (polystyrene n = 1.59). If the incident angle is 25 degrees, what is the angle of refraction?

$1,33 \sin(25) = 1,59 \sin(\varnothing r)$

3. A light ray moves from sapphire (n = 1.77) to air (n = 1.0001). The light ray bends [✓ toward]/away (circle one) from the normal.

4. Electromagnetic, are waves that consist of oscillating electric and magnetic fields.

5. Can electromagnetic waves can travel through a vacuum? [✓ Yes]/No (circle one)

6. What color is reflected off of green grass?

Green

7. What colors make up white and black light?

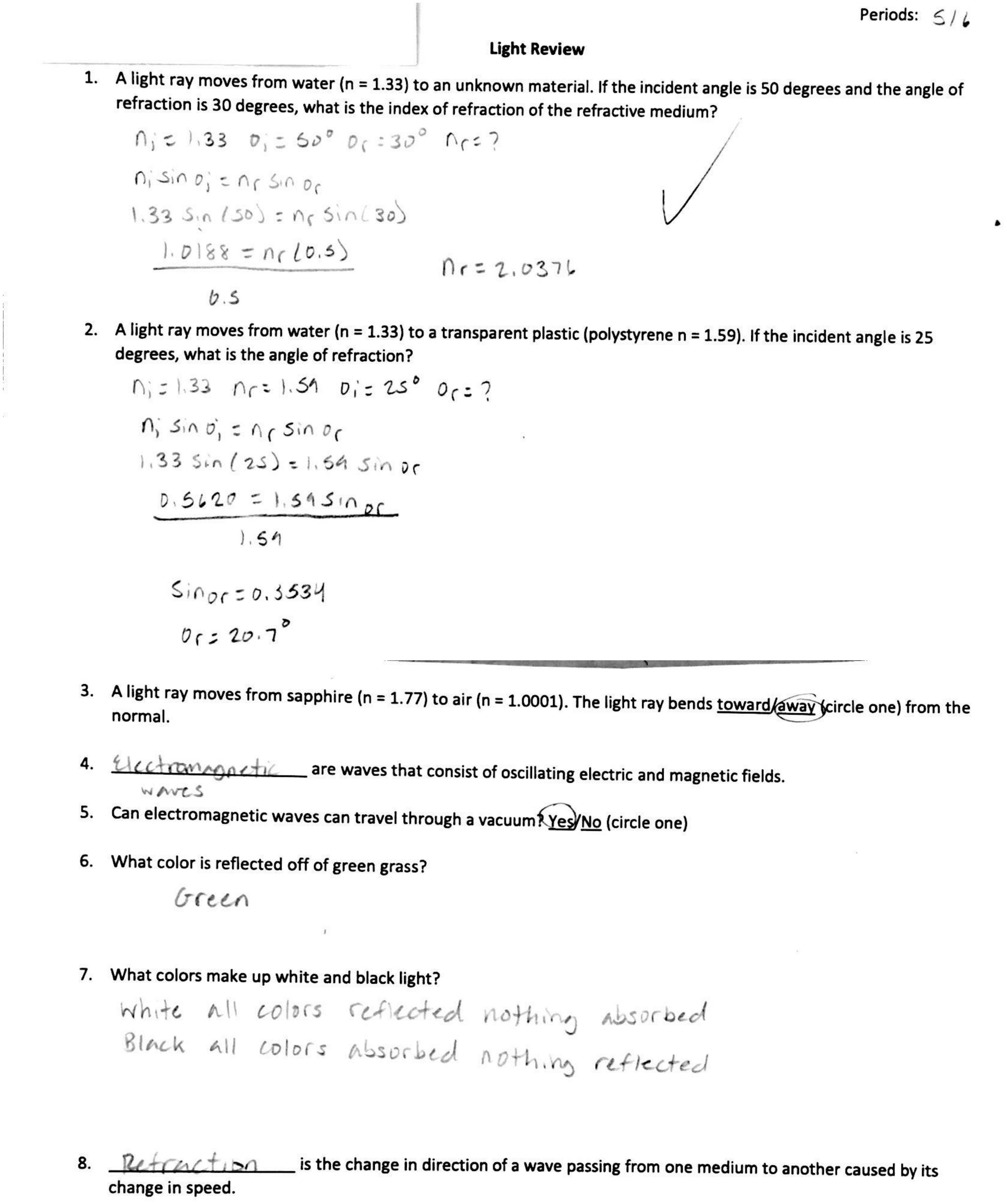
White = all

Black = None.

8. Refraction is the change in direction of a wave passing from one medium to another caused by its change in speed.

Appendix F: Student Work - Exemplary Homework

Page 1 of 1



Periods: 5/6

Light Review

1. A light ray moves from water (n = 1.33) to an unknown material. If the incident angle is 50 degrees and the angle of refraction is 30 degrees, what is the index of refraction of the refractive medium?

$n_i = 1.33$ $\theta_i = 50°$ $\theta_r = 30°$ $n_r = ?$

$n_i \sin\theta_i = n_r \sin\theta_r$

$1.33 \sin(50) = n_r \sin(30)$

$$\frac{1.0188 = n_r (0.5)}{0.5}$$

$n_r = 2.0376$

✓

2. A light ray moves from water (n = 1.33) to a transparent plastic (polystyrene n = 1.59). If the incident angle is 25 degrees, what is the angle of refraction?

$n_i = 1.33$ $n_r = 1.59$ $\theta_i = 25°$ $\theta_r = ?$

$n_i \sin\theta_i = n_r \sin\theta_r$

$1.33 \sin(25) = 1.59 \sin\theta_r$

$$\frac{0.5620 = 1.59 \sin\theta_r}{1.59}$$

$\sin\theta_r = 0.3534$

$\theta_r = 20.7°$

3. A light ray moves from sapphire (n = 1.77) to air (n = 1.0001). The light ray bends toward/[✓ away] (circle one) from the normal.

4. Electromagnetic waves are waves that consist of oscillating electric and magnetic fields.

5. Can electromagnetic waves can travel through a vacuum? [✓ Yes]/No (circle one)

6. What color is reflected off of green grass?

Green

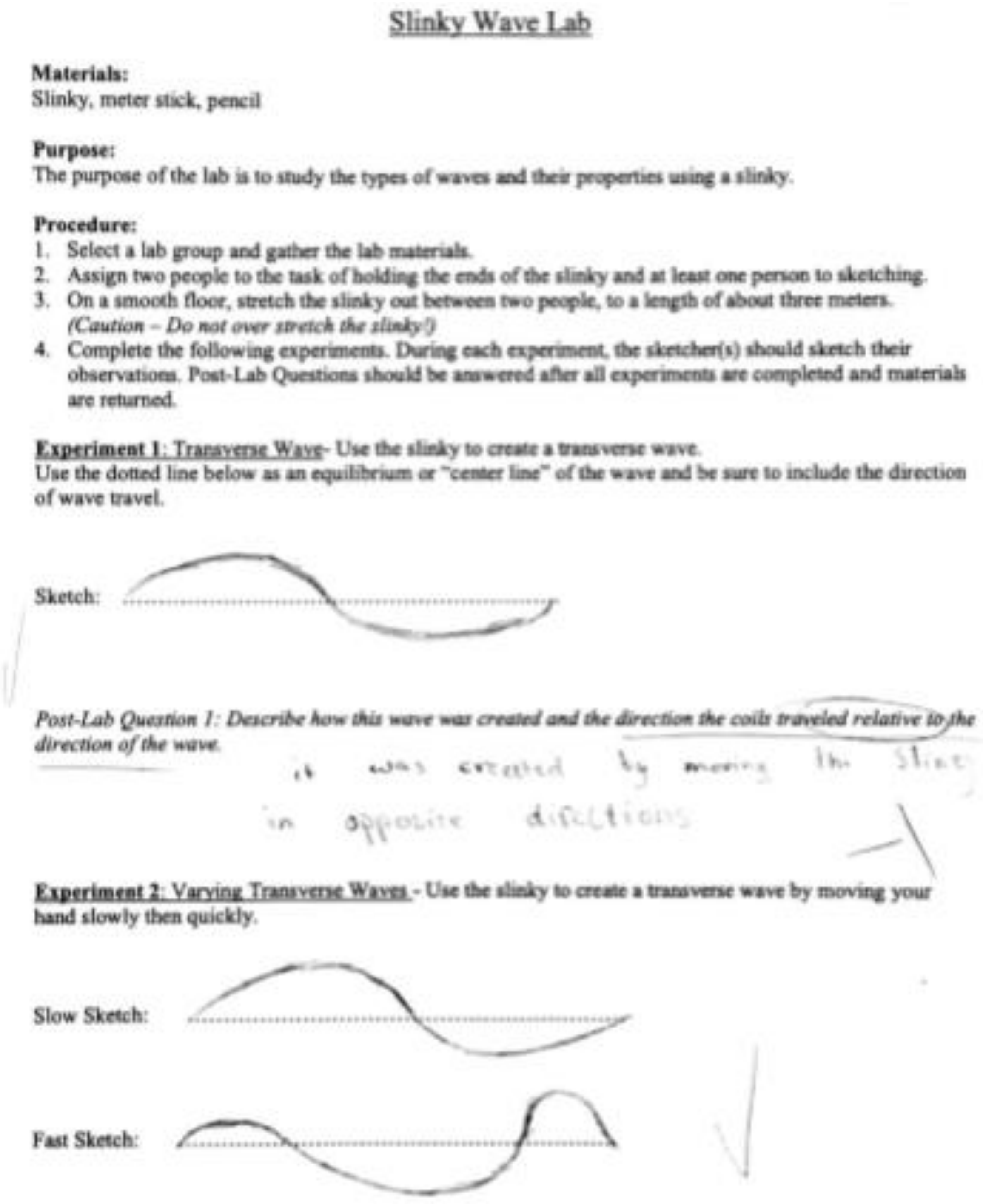
7. What colors make up white and black light?

White all colors reflected nothing absorbed
Black all colors absorbed nothing reflected

8. Refraction is the change in direction of a wave passing from one medium to another caused by its change in speed.

Appendix G: Incomplete Lab

Page 1 of 4



Slinky Wave Lab

Materials:
Slinky, meter stick, pencil

Purpose:
The purpose of the lab is to study the types of waves and their properties using a slinky.

Procedure:

1. Select a lab group and gather the lab materials.
2. Assign two people to the task of holding the ends of the slinky and at least one person to sketching.
3. On a smooth floor, stretch the slinky out between two people, to a length of about three meters. *(Caution – Do not over stretch the slinky!)*
4. Complete the following experiments. During each experiment, the sketcher(s) should sketch their observations. Post-Lab Questions should be answered after all experiments are completed and materials are returned.

<u>Experiment 1</u>: <u>Transverse Wave</u>- Use the slinky to create a transverse wave.
Use the dotted line below as an equilibrium or "center line" of the wave and be sure to include the direction of wave travel.

Sketch:

Post-Lab Question 1: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave.

it was created by moving the slinky in opposite directions

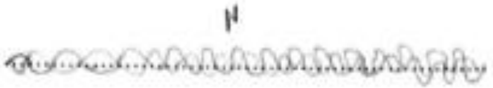
<u>Experiment 2</u>: <u>Varying Transverse Waves</u> - Use the slinky to create a transverse wave by moving your hand slowly then quickly.

Slow Sketch:

Fast Sketch:

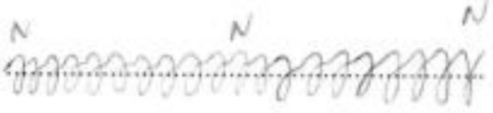
Post-Lab Question 2: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths. One wave was constant or similar as the other wasn't.

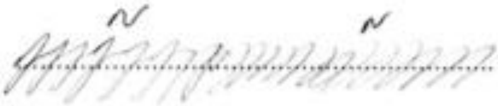
Experiment 3: Longitudinal Wave- Use the slinky to create a longitudinal wave.

Sketch: 

Post-Lab Question 3: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave.

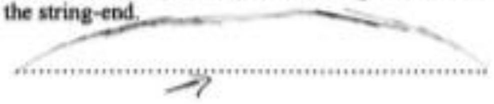
Experiment 4: Varying Longitudinal Waves - Use the slinky to create a longitudinal wave by moving your hand slowly then quickly.

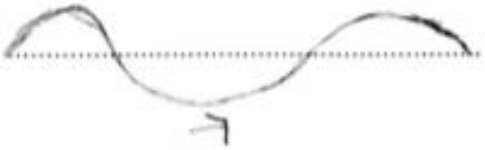
Slow Sketch: 

Fast Sketch: 

Post-Lab Question 4: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths.

Experiment 5: Free End- Hold one end of the slinky loosely with a string and the other end with your hand. Send one pulse down the slinky to the string-end.

Sketch before reaching the end: 

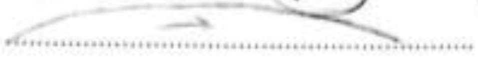
Sketch after reaching the end: 

Post-Lab Question 5: Describe what happened to the pulse after it reached the end.

-2

Experiment 6: Fixed End- Hold both ends of the slinky. Send one pulse down the slinky.

Sketch before reaching the end:



Sketch after reaching the end:

-1

Post-Lab Question 6: Describe what happened to the pulse after it reached the end.

one stayed the same and the other wasn't

-1

Experiment 7: Two Pulses 1- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on the same side.

Sketch before pulses reach each other:

Sketch after pulses reach each other:

-1

Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this? they bounced back, switched sides.

-1

Experiment 8: Two Pulses 2- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on opposite sides.

Sketch before pulses reach each other:

Sketch after pulses reach each other:

-1

Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this?

−2

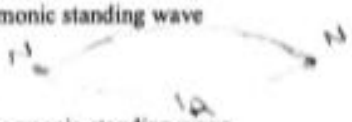
Additional Post-Lab Questions

1. For each wave produced did any of the spring coils actually travel from one end of the slinky to another?
   yes because it was reflected off the end of the Slinky

   No, waves carry energy!
2. If the wave coils did not travel than what did?
   the pulse
3. Describe how you might create a standing wave using the slinky.
   One person moves the slinky to the left and the other to the right
4. Sketch what your standing wave would look like and label **all** nodes and antinodes

5. Assume your slinky is 3m in length in order to calculate the wavelength needed to create the harmonics below.

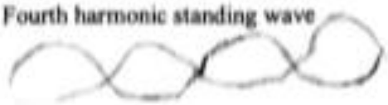
a. First harmonic standing wave



b. Second harmonic standing wave

c. Third harmonic standing wave

d. Fourth harmonic standing wave



Appendix H: Satisfactory Lab – ELL Student Level 4

Page 1 of 4

Periods: 5/6

Slinky Wave Lab

33/40

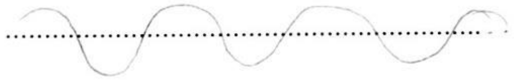
Materials:
Slinky, meter stick, pencil

Purpose:
The purpose of the lab is to study the types of waves and their properties using a slinky.

Procedure:
1. Select a lab group and gather the lab materials.
2. Assign two people to the task of holding the ends of the slinky and at least one person to sketching.
3. On a smooth floor, stretch the slinky out between two people, to a length of about three meters. *(Caution – Do not over stretch the slinky!)*
4. Complete the following experiments. During each experiment, the sketcher(s) should sketch their observations. Post-Lab Questions should be answered after all experiments are completed and materials are returned.

Experiment 1: Transverse Wave- Use the slinky to create a transverse wave.
Use the dotted line below as an equilibrium or "center line" of the wave and be sure to include the direction of wave travel.

Sketch:



−1

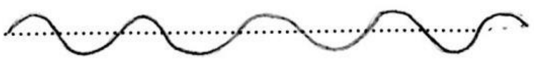
Post-Lab Question 1: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave.

The wave in which the particles move was perpendicular to the wave motion

Experiment 2: Varying Transverse Waves - Use the slinky to create a transverse wave by moving your hand slowly then quickly.

Slow Sketch:

Fast Sketch:



Post-Lab Question 2: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths.

- When the waves are moving slowly the amplitude as higher the wavelengths are wider and the frequencies are less waves per second.
- When the waves are moving quickly the amplitude and wavelengths and the wavelengths decrease and the frequencies are more per second.

Experiment 3: Longitudinal Wave- Use the slinky to create a longitudinal wave.

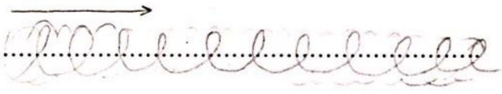
Sketch:

-1

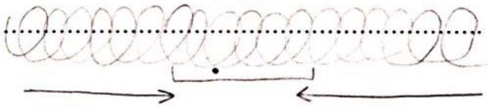
Post-Lab Question 3: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave. A wave in which the particles move was parallel to the wave motion.

Experiment 4: Varying Longitudinal Waves - Use the slinky to create a longitudinal wave by moving your hand slowly then quickly.

Slow Sketch:



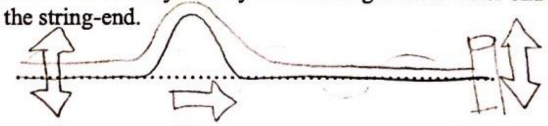
Fast Sketch:



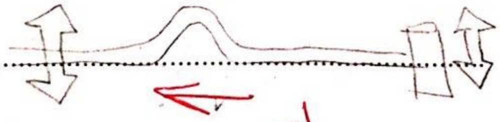
Post-Lab Question 4: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths. When we move our hand slowly the waves move constantly going to one direction. higher frequencies and amplitudes, wavelengths decrease When it move quickly the waves collide together and they follow opposite directions. Lower frequencies and amplitudes, wavelengths increase

Experiment 5: Free End- Hold one end of the slinky loosely with a string and the other end with your hand. Send one pulse down the slinky to the string-end.

Sketch before reaching the end:



Sketch after reaching the end:



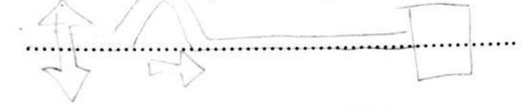
-1

Post-Lab Question 5: Describe what happened to the pulse after it reached the end.

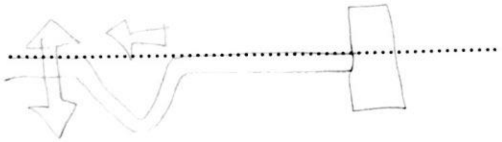
When the pulse is delivered after it reached the end it went backwards up and down to the opposite direction.

Experiment 6: Fixed End- Hold both ends of the slinky. Send one pulse down the slinky.

Sketch before reaching the end:



Sketch after reaching the end:

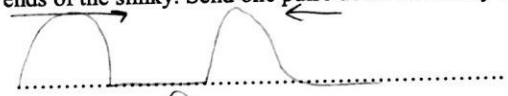


Post-Lab Question 6: Describe what happened to the pulse after it reached the end.

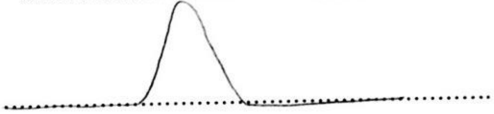
After it reached the end it switch position going downwards going to the opposite position.

Experiment 7: Two Pulses 1- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on the same side.

Sketch before pulses reach each other:



Sketch after pulses reach each other:

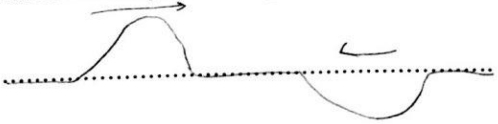


Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this?

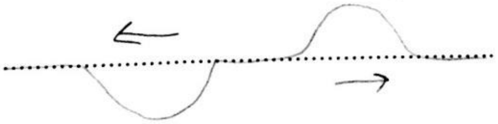
The waves become a constructive interference and the point of superposition has a greater amplitude than the two individual pulses

Experiment 8: Two Pulses 2- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on opposite sides.

Sketch before pulses reach each other:



Sketch after pulses reach each other:



Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this?

Destructive interference occurs when the point of superposition has an amplitude less than individual pulses.

Additional Post-Lab Questions

1. For each wave produced did any of the spring coils actually travel from one end of the slinky to another?

No

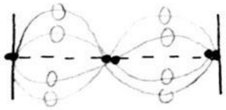
2. If the wave coils did not travel than what did?

~~Energy~~ Waves only transfer energy, not particles

3. Describe how you might create a standing wave using the slinky.

One that has nodes at the two ends of the slinky and one antinode in the middle.

4. Sketch what your standing wave would look like and label **all** nodes and antinodes

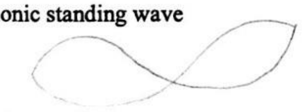


○ Antinodes
• Nodes

5. Assume your slinky is 3m in length in order to calculate the wavelength needed to create the harmonics below.

a. First harmonic standing wave

b. Second harmonic standing wave



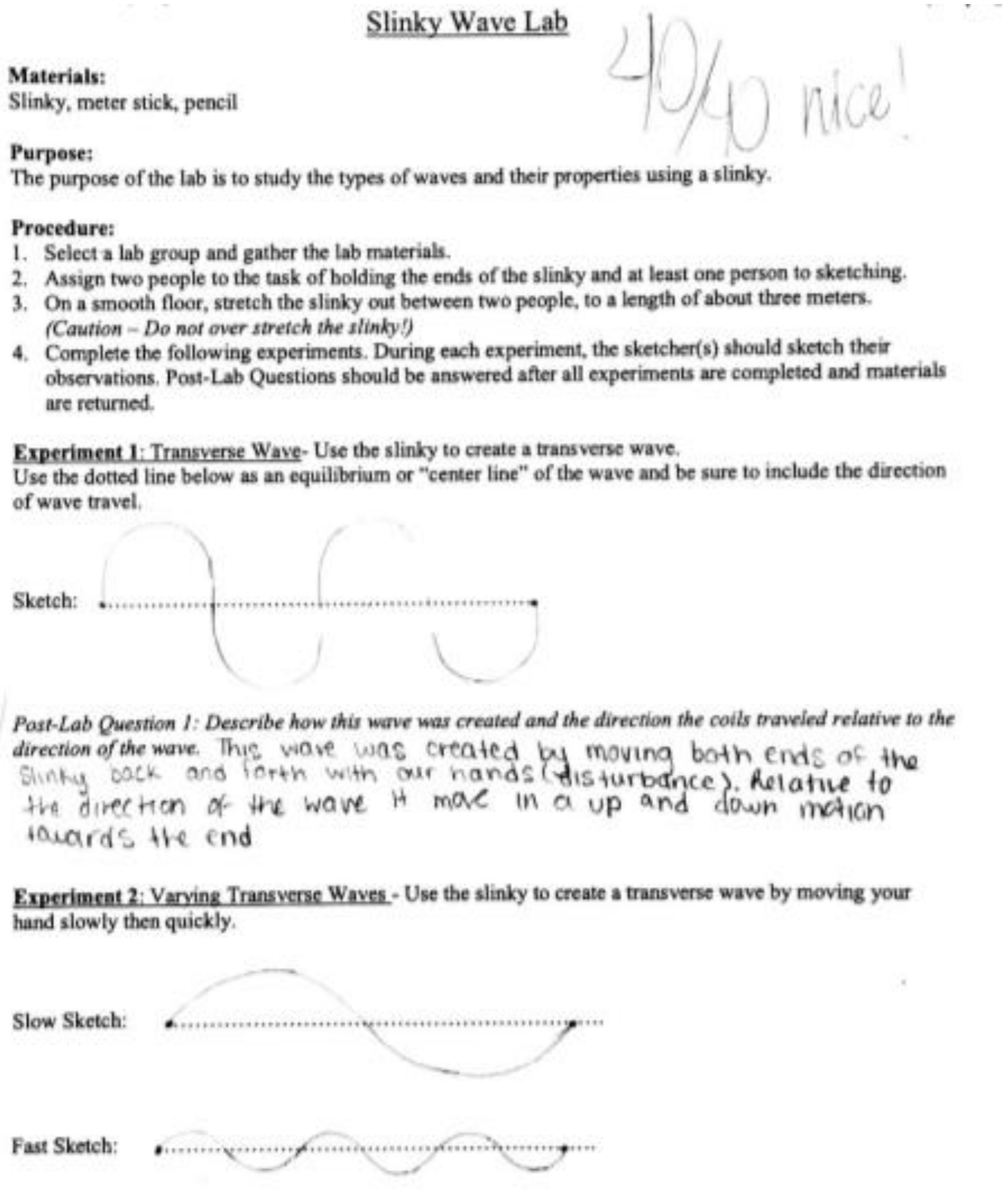
-4

c. Third harmonic standing wave

d. Fourth harmonic standing wave

Appendix I: Exemplary Lab

Page 1 of 4



Slinky Wave Lab

40/40 nice!

Materials:
Slinky, meter stick, pencil

Purpose:
The purpose of the lab is to study the types of waves and their properties using a slinky.

Procedure:

1. Select a lab group and gather the lab materials.
2. Assign two people to the task of holding the ends of the slinky and at least one person to sketching.
3. On a smooth floor, stretch the slinky out between two people, to a length of about three meters. *(Caution – Do not over stretch the slinky!)*
4. Complete the following experiments. During each experiment, the sketcher(s) should sketch their observations. Post-Lab Questions should be answered after all experiments are completed and materials are returned.

Experiment 1: Transverse Wave- Use the slinky to create a transverse wave.
Use the dotted line below as an equilibrium or "center line" of the wave and be sure to include the direction of wave travel.

Sketch:

✓ *Post-Lab Question 1: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave.* This wave was created by moving both ends of the slinky back and forth with our hands (disturbance). Relative to the direction of the wave it move in a up and down motion towards the end

Experiment 2: Varying Transverse Waves - Use the slinky to create a transverse wave by moving your hand slowly then quickly.

Slow Sketch:

Fast Sketch:

Post-Lab Question 2: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths. The Slow wave has a larger amplitude and wave length but has a Smaller Frequency than the fast wave.

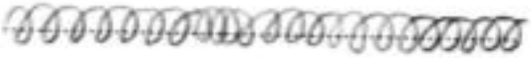
Experiment 3: Longitudinal Wave- Use the slinky to create a longitudinal wave.

Sketch:

Post-Lab Question 3: Describe how this wave was created and the direction the coils traveled relative to the direction of the wave. This wave was created by pushing one side of the slinky with our hand (disturbance). The wave moved In the direction of where we Pushed.

Experiment 4: Varying Longitudinal Waves - Use the slinky to create a longitudinal wave by moving your hand slowly then quickly.

Slow Sketch:



Fast Sketch:

Post-Lab Question 4: Compare the two waves and describe the similarities and differences of the waves' frequencies, amplitudes, and wavelengths. The wave that was made by pushing slowly had More space in between the coils as it traveled, The slow wave has a smaller Frequency than the Fast wave but it has a larger wavelength. The fast wave has less space inbetween the coils and has the same amplitude as the slow wave.

Experiment 5: Free End- Hold one end of the slinky loosely with a string and the other end with your hand. Send one pulse down the slinky to the string-end.

Sketch before reaching the end:

Sketch after reaching the end:

Post-Lab Question 5: Describe what happened to the pulse after it reached the end.
After it got to the end the wave traveled back to where it started by bouncing off the end

Experiment 6: Fixed End- Hold both ends of the slinky. Send one pulse down the slinky.

Sketch before reaching the end:

Sketch after reaching the end:

Post-Lab Question 6: Describe what happened to the pulse after it reached the end.
After the pulse reached the end it flipped upside-down and traveled back to where it started.

Experiment 7: Two Pulses 1- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on the same side.

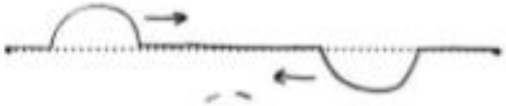
Sketch before pulses reach each other:

Sketch after pulses reach each other:

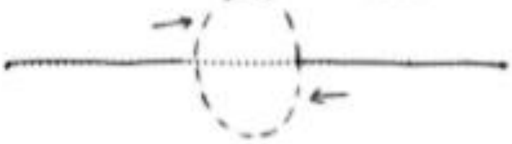
Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this? The pulses combined when they reached other to make a larger pulse. This is known as constructive inference.
(point of superposition)
(amplitude increases)

Experiment 8: Two Pulses 2- Hold both ends of the slinky. Send one pulse down the slinky from each end, starting the pulses on opposite sides.

Sketch before pulses reach each other:



Sketch after pulses reach each other:



Post-Lab Question 7: Describe what happened to the pulses when they reached each other. What type of interference is this? when they reach other the pulses collide. making a point of superposition where the amplitude is less than their individual pulses, this is Destructive inference.

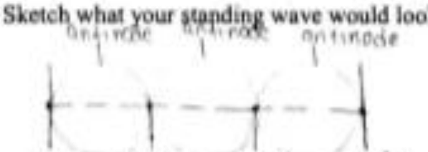
Additional Post-Lab Questions

1. **For each wave produced did any of the spring coils actually travel from one end of the slinky to another?**
No, the spring coils did not; waves transfer energy not particles.

2. **If the wave coils did not travel than what did?**
Energy travels through the coils.

3. **Describe how you might create a standing wave using the slinky.**
You could create a standard wave with the slinky by moving at a fast speed so it appears as if the slinky is stationary.

4. **Sketch what your standing wave would look like and label all nodes and antinodes**



5. **Assume your slinky is 3m in length in order to calculate the wavelength needed to create the harmonics below.**

a. **First harmonic standing wave**

$\frac{2L}{n}$ $\frac{2(3)}{1} = \boxed{6m}$

b. **Second harmonic standing wave**

$\frac{2(3)}{2} = \boxed{3m}$

c. **Third harmonic standing wave**

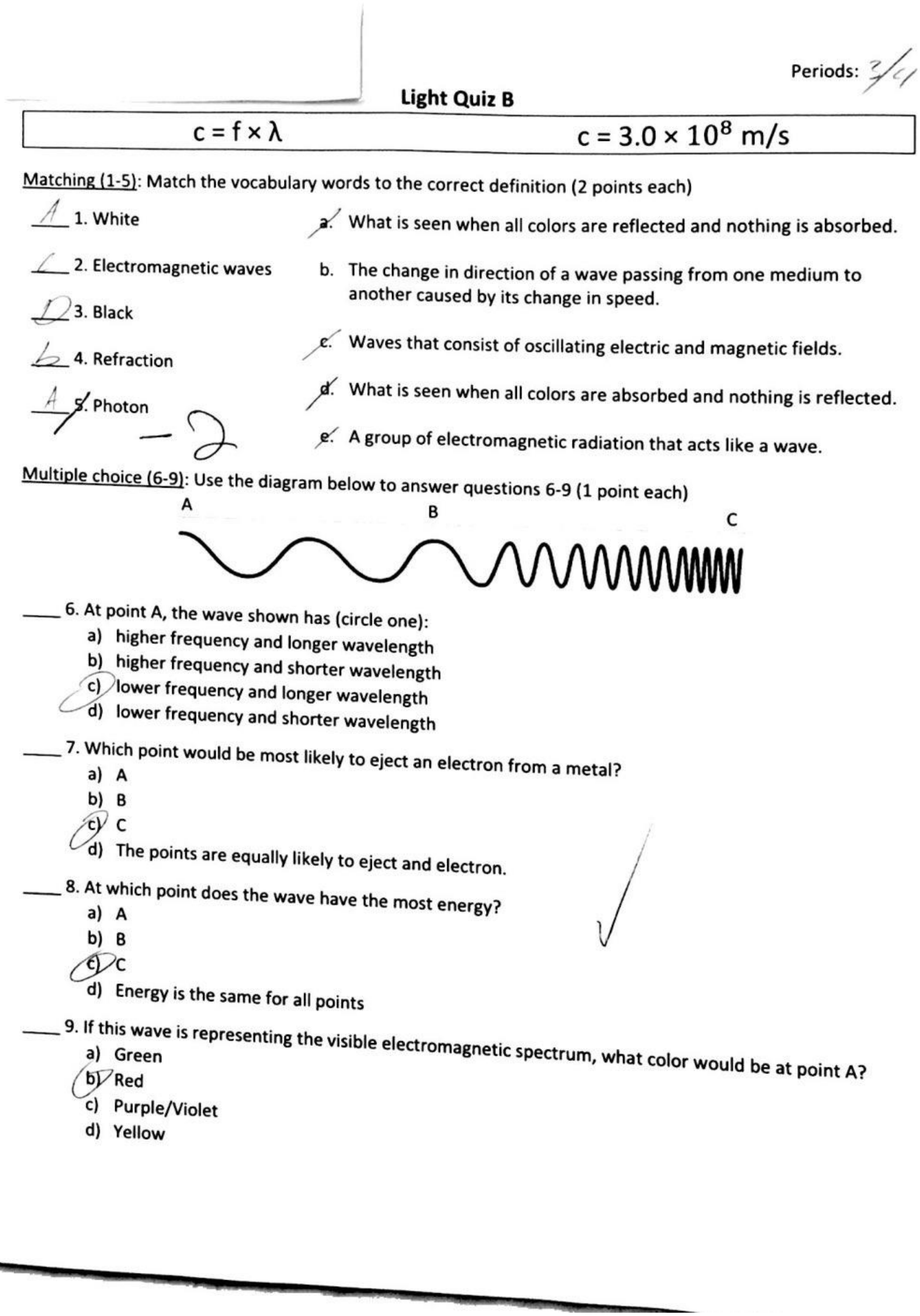
$\frac{2(3)}{3} = \boxed{2m}$

d. **Fourth harmonic standing wave**

$\frac{2(3)}{4} = \boxed{1.5m}$

Appendix J: Incomplete Summative Assessment

Page 1 of 2



Periods: 3/4

Light Quiz B

c = f × λ	c = 3.0 × 10⁸ m/s

Matching (1-5): Match the vocabulary words to the correct definition (2 points each)

A 1. White
C 2. Electromagnetic waves
D 3. Black
b 4. Refraction
A 5. Photon

— 2

a. What is seen when all colors are reflected and nothing is absorbed.
b. The change in direction of a wave passing from one medium to another caused by its change in speed.
c. Waves that consist of oscillating electric and magnetic fields.
d. What is seen when all colors are absorbed and nothing is reflected.
e. A group of electromagnetic radiation that acts like a wave.

Multiple choice (6-9): Use the diagram below to answer questions 6-9 (1 point each)

A
B
C

____ 6. At point A, the wave shown has (circle one):
- a) higher frequency and longer wavelength
- b) higher frequency and shorter wavelength
- [✓ c)] lower frequency and longer wavelength
- d) lower frequency and shorter wavelength

____ 7. Which point would be most likely to eject an electron from a metal?
- a) A
- b) B
- [✓ c)] C
- d) The points are equally likely to eject and electron.

✓

____ 8. At which point does the wave have the most energy?
- a) A
- b) B
- [✓ c)] C
- d) Energy is the same for all points

____ 9. If this wave is representing the visible electromagnetic spectrum, what color would be at point A?
- a) Green
- [✓ b)] Red
- c) Purple/Violet
- d) Yellow

Concept Questions (10-11): Use your knowledge of light to answer the following questions. Be sure to use complete sentences. (4 points each)

10. Use an example to explain the role of absorption and reflection in how we see color.

−1

absorbtion Takes in all The Colors and Reflects The Colors we See

Reflection Bounces off of The obJects

11. Which experiment proved light acts like a particle? Briefly explain how this experiment proved this. If needed, include a sketch along with your explanation.

−2

Photoelectric effect

Calculation (12): Answer the following question. Be sure to include givens, necessary formulas, calculations and the correct answer with units. (5 points)

12. Red light travels through a vacuum with a wavelength of 680 × 10^{-9} m. What is the frequency of this wave?

$C = f\lambda$

$$\frac{3\times10^{8} = f\ 680\times10^{-9}}{680\times10^{-9}}$$

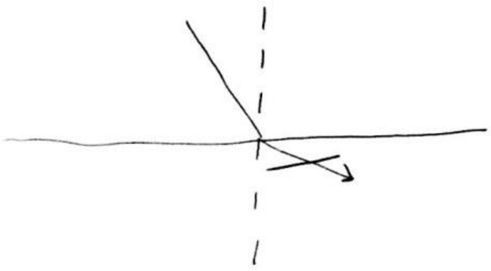
f = ?

Givens?

−3

Sketch (13): Use your knowledge of light complete the following sketch. (3 points)

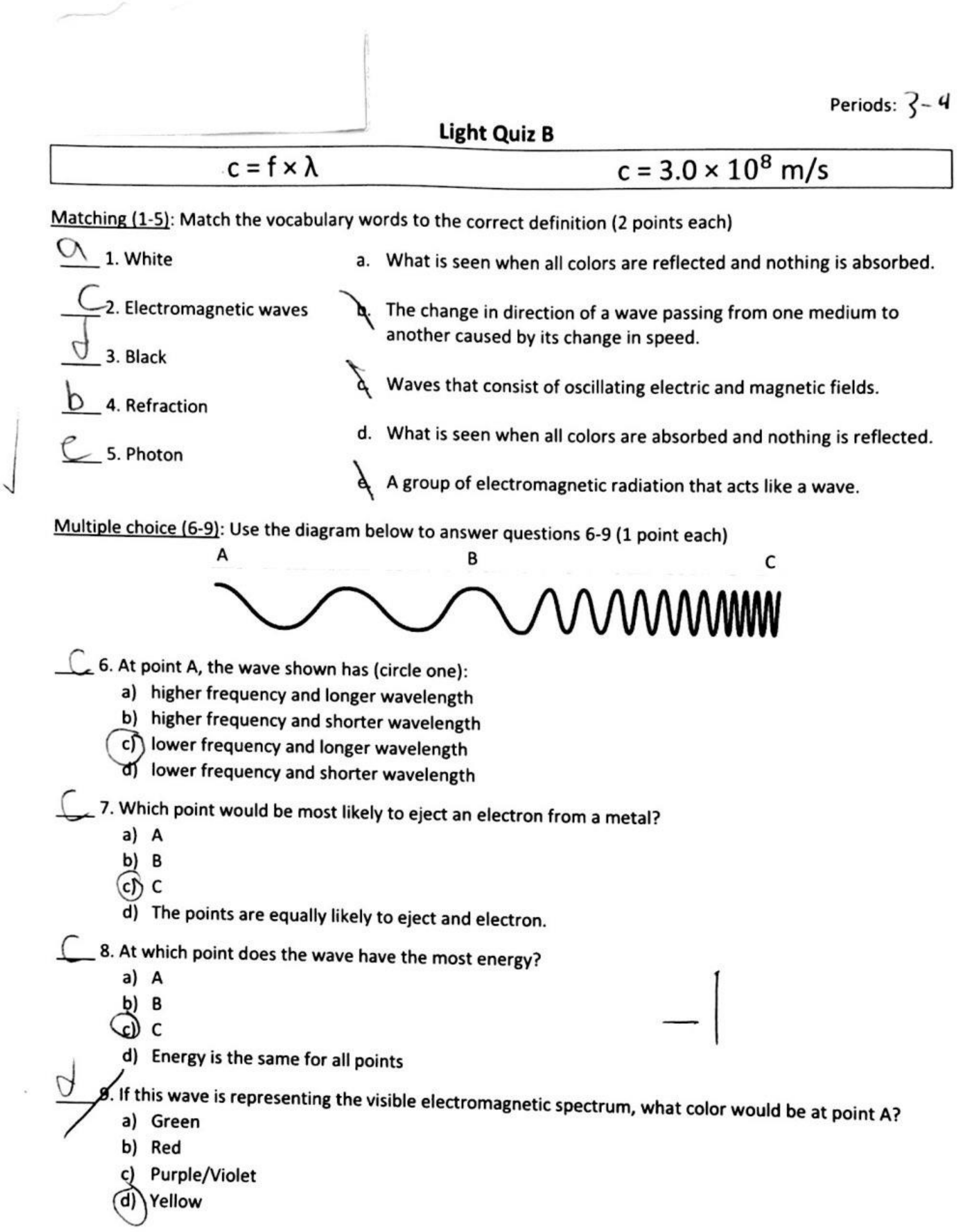
13. Draw a sketch showing what happens when light travels from a material with a low index of refraction to a material with a high index of refraction. Be sure to include the incident ray, refracted ray and normal line.



−1

$\frac{21}{30}$

Appendix K: Satisfactory Summative Assessment – SPED Student Page 1 of 2



Periods: 3-4

Light Quiz B

$c = f \times \lambda$ $c = 3.0 \times 10^8$ m/s

Matching (1-5): Match the vocabulary words to the correct definition (2 points each)

a 1. White	a. What is seen when all colors are reflected and nothing is absorbed.
c 2. Electromagnetic waves	b. The change in direction of a wave passing from one medium to another caused by its change in speed.
d 3. Black	c. Waves that consist of oscillating electric and magnetic fields.
b 4. Refraction	d. What is seen when all colors are absorbed and nothing is reflected.
e 5. Photon	e. A group of electromagnetic radiation that acts like a wave.

Multiple choice (6-9): Use the diagram below to answer questions 6-9 (1 point each)

A B C

c 6. At point A, the wave shown has (circle one):
- a) higher frequency and longer wavelength
- b) higher frequency and shorter wavelength
- [✓ c) lower frequency and longer wavelength]
- d) lower frequency and shorter wavelength

c 7. Which point would be most likely to eject an electron from a metal?
- a) A
- b) B
- [✓ c) C]
- d) The points are equally likely to eject and electron.

c 8. At which point does the wave have the most energy?
- a) A
- b) B
- [✓ c) C]
- d) Energy is the same for all points

d 9. If this wave is representing the visible electromagnetic spectrum, what color would be at point A?
- a) Green
- b) Red
- c) Purple/Violet
- [✓ d) Yellow]

Concept Questions (10-11): Use your knowledge of light to answer the following questions. Be sure to use complete sentences. (4 points each)

10. Use an example to explain the role of absorption and reflection in how we see color.

-1

~~When~~ we don't see any color that is absorbed in an object, but we see the color that is reflected from an object

-2

11. Which experiment proved light acts like a particle? Briefly explain how this experiment proved this. If needed, include a sketch along with your explanation.

C:-

Photoelectric effect.

C .f c

Calculation (12): Answer the following question. Be sure to include givens, necessary formulas, calculations and the correct answer with units. (5 points)

12. Red light travels through a vacuum with a wavelength of 680 × 10^{-9} m. What is the frequency of this wave?

$\lambda = 680 \times 10^{-9}$ m   f = ? $c = 3 \times 10^{8}$ m/s

$c = f \times \lambda$ c = 3,000,000,000

3,000,000,000 = $f \times \lambda$

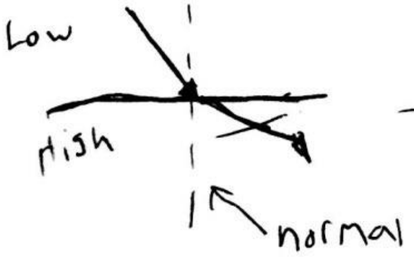
3,000,000,000 = $f \times \frac{-6.8''}{6.8}$

f = ~~44117~~6470.6 Hz

-1

Sketch (13): Use your knowledge of light complete the following sketch. (3 points)

13. Draw a sketch showing what happens when light travels from a material with a low index of refraction to a material with a high index of refraction. Be sure to include the incident ray, refracted ray and normal line.



-1

24/30

Appendix L: Exemplary Summative Assessment

Page 1 of 2

Periods: 3/4 A

Light Quiz A

$c = f \times \lambda$ $c = 3.0 \times 10^8$ m/s

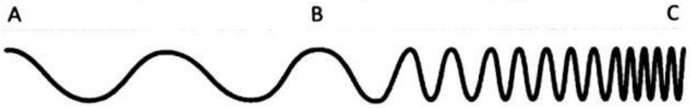
Matching (1-5): Match the vocabulary words to the correct definition (2 points each)

E 1. White
B 2. Electromagnetic waves
D 3. Black
A 4. Refraction
C 5. Photon

✓

a. The change in direction of a wave passing from one medium to another caused by its change in speed.
b. Waves that consist of oscillating electric and magnetic fields.
c. A group of electromagnetic radiation that acts like a wave.
d. What is seen when all colors are absorbed and nothing is reflected.
e. What is seen when all colors are reflected and nothing is absorbed.

Multiple choice (6-9): Use the diagram below to answer questions 6-9 (1 point each)



B 6. At point A, the wave shown has (circle one):
- a) lower frequency and shorter wavelength
- b) lower frequency and longer wavelength
- c) higher frequency and shorter wavelength
- d) higher frequency and longer wavelength

C 7. At which point does the wave have the most energy?
- a) A
- b) B
- c) C
- d) Energy is the same for all points

D 8. If this wave is representing the visible electromagnetic spectrum, what color would be at point A?
- a) Purple/Violet
- b) Yellow
- c) Green
- d) Red

RoyGBIV

C 9. Which point would be most likely to eject an electron from a metal?
- a) A
- b) B
- c) C
- d) The points are equally likely to eject and electron.

✓

Calculation (10): Answer the following question. Be sure to include givens, necessary formulas, calculations and the correct answer with units. (5 points)

10. Green light travels through a vacuum with a wavelength of 540×10^{-9} m. What is the frequency of this wave?

$C = 3.0 \times 10^{8}$ m/s $h = 540 \times 10^{-9}$ m $f = ?$

$C = fh$

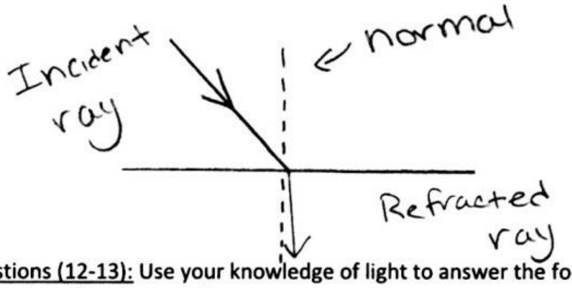
$$\frac{3.0 \times 10^{8} = 540 \times 10^{-9} f}{540 \times 10^{-9}}$$

$\boxed{f = 5.5 \times 10^{14} hz}$

✓

Sketch (11): Use your knowledge of light complete the following sketch. (3 points)

11. Draw a sketch showing what happens when light travels from a material with a low index of refraction to a material with a high index of refraction. Be sure to include the incident ray, refracted ray and normal line.



✓

29/30

Concept Questions (12-13): Use your knowledge of light to answer the following questions. Be sure to use complete sentences. (4 points each)

12. Use an example to explain the role of absorption and reflection in how we see color.

An example would be an apple. Absorption would be all the colors going through the apple but the apples reflection would be red.

✓

13. Which experiment proved light acts like a particle? Briefly explain how this experiment proved this. If needed, include a sketch along with your explanation.

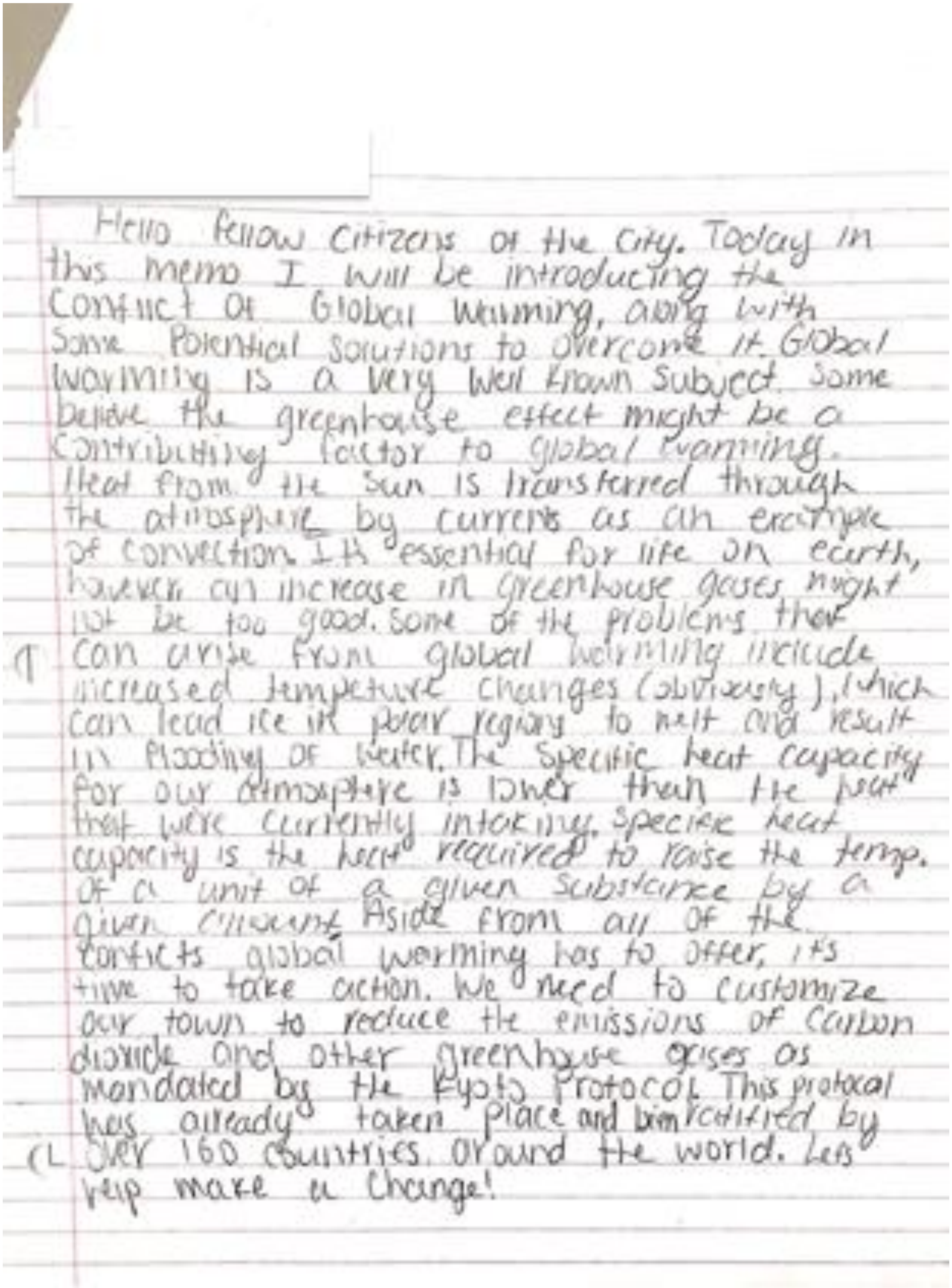
✓ Photoelectric effect is when higher frequencys Show more electrons. For example if you turn up the intensity on a light & have a ray of red you dont see electrons. But if you Change the ray to violet you Can see the electons float in.

?

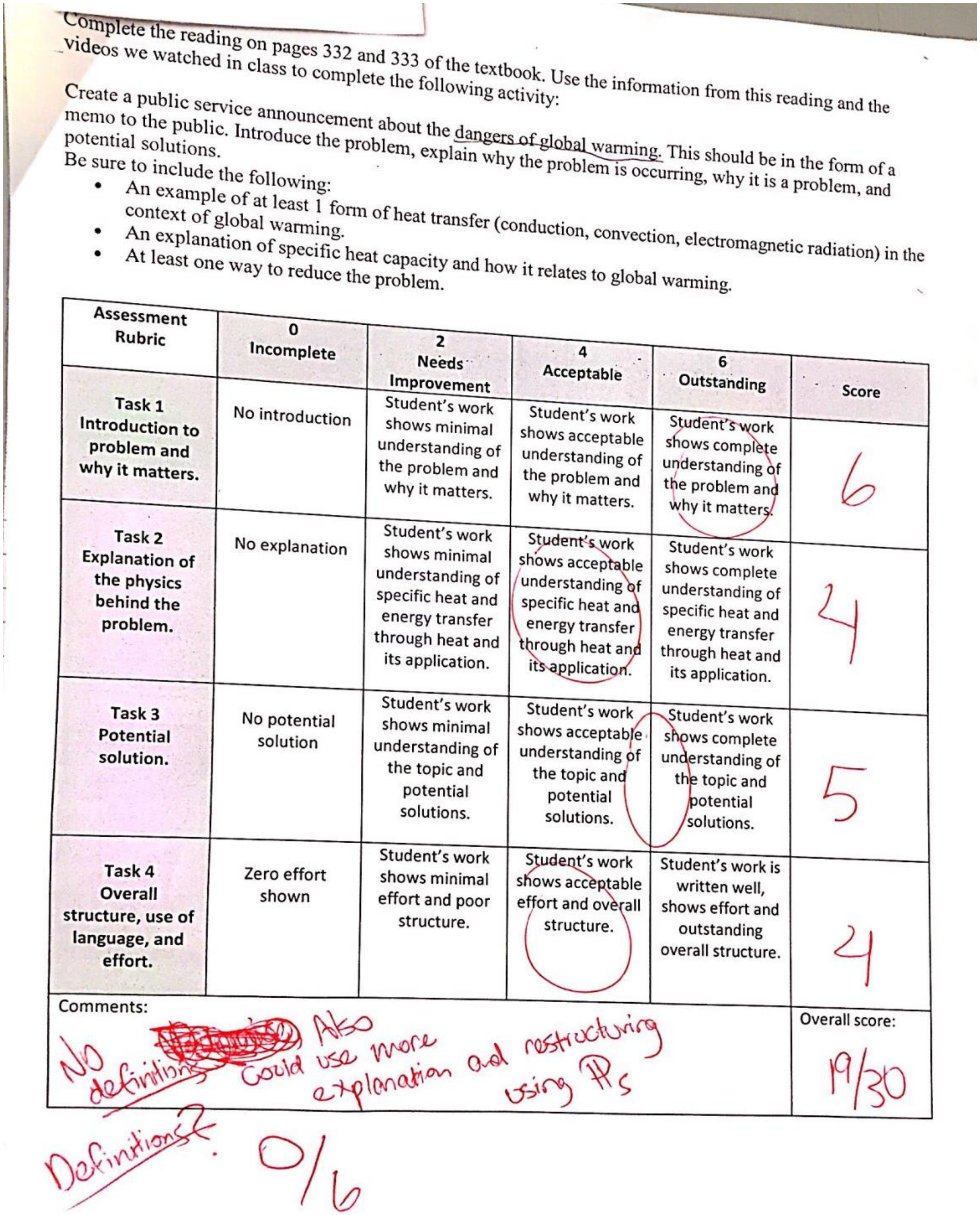
-1

Appendix M: Incomplete Alternative Assessment

Page 1 of 2



Hello fellow citizens of the city. Today in
this memo I will be introducing the
conflict of Global Warming, along with
some potential solutions to overcome it. Global
warming is a very well known subject. Some
believe the greenhouse effect might be a
contributing factor to global warming.
Heat from the sun is transferred through
the atmosphere by currents as an example
of convection. It's essential for life on earth,
however an increase in greenhouse gases might
not be too good. Some of the problems that
¶ can arise from global warming include
increased tempeture changes (obviously), which
can lead ice in polar regions to melt and result
in flooding of water. The specific heat capacity
for our atmosphere is lower than the heat
that were currently intaking. Specific heat
capacity is the heat required to raise the temp.
of a unit of a given substance by a
given amount. Aside from all of the
conflicts global warming has to offer, it's
time to take action. We need to customize
our town to reduce the emissions of carbon
dioxide and other greenhouse gases as
mandated by the Kyoto Protocol. This protocal
has already taken place and been ratified by
CL over 160 countries around the world. Lets
help make a change!



Complete the reading on pages 332 and 333 of the textbook. Use the information from this reading and the videos we watched in class to complete the following activity:

Create a public service announcement about the dangers of global warming. This should be in the form of a memo to the public. Introduce the problem, explain why the problem is occurring, why it is a problem, and potential solutions.

Be sure to include the following:

- An example of at least 1 form of heat transfer (conduction, convection, electromagnetic radiation) in the context of global warming.
- An explanation of specific heat capacity and how it relates to global warming.
- At least one way to reduce the problem.

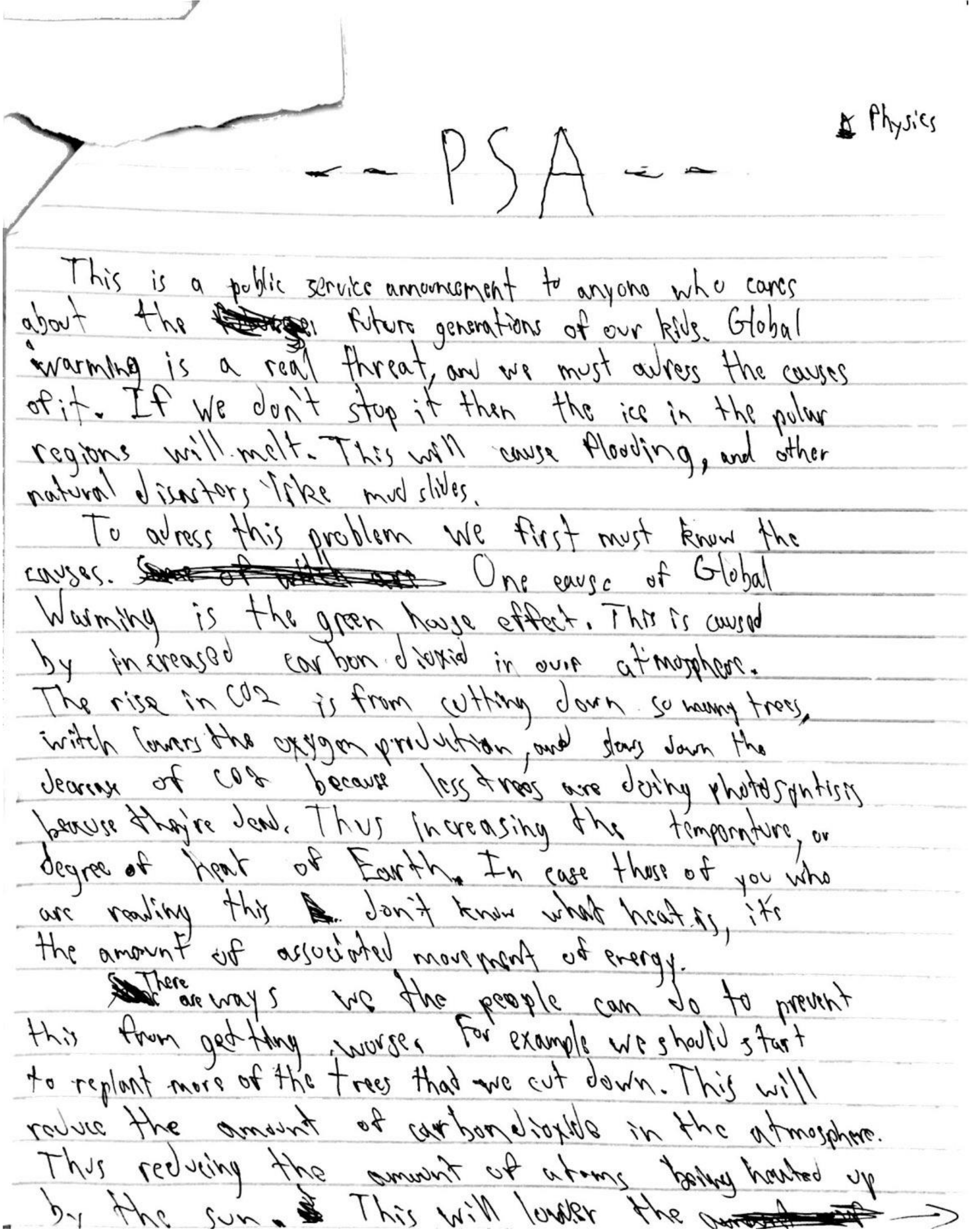
Assessment Rubric	0 Incomplete	2 Needs Improvement	4 Acceptable	6 Outstanding	Score
Task 1 Introduction to problem and why it matters.	No introduction	Student's work shows minimal understanding of the problem and why it matters.	Student's work shows acceptable understanding of the problem and why it matters.	[✓ Student's work shows complete understanding of the problem and why it matters.]	6
Task 2 Explanation of the physics behind the problem.	No explanation	Student's work shows minimal understanding of specific heat and energy transfer through heat and its application.	[✓ Student's work shows acceptable understanding of specific heat and energy transfer through heat and its application.]	Student's work shows complete understanding of specific heat and energy transfer through heat and its application.	4
Task 3 Potential solution.	No potential solution	Student's work shows minimal understanding of the topic and potential solutions.	Student's work shows acceptable understanding of the topic and potential solutions.	Student's work shows complete understanding of the topic and potential solutions.	5
Task 4 Overall structure, use of language, and effort.	Zero effort shown	Student's work shows minimal effort and poor structure.	[✓ Student's work shows acceptable effort and overall structure.]	Student's work is written well, shows effort and outstanding overall structure.	4
Comments: No definitions [redacted] Also Could use more explanation and restructuring using ¶s					Overall score: 19/30

Definitions?

0/6

Appendix N: Satisfactory Alternative Assessment

Page 1 of 3



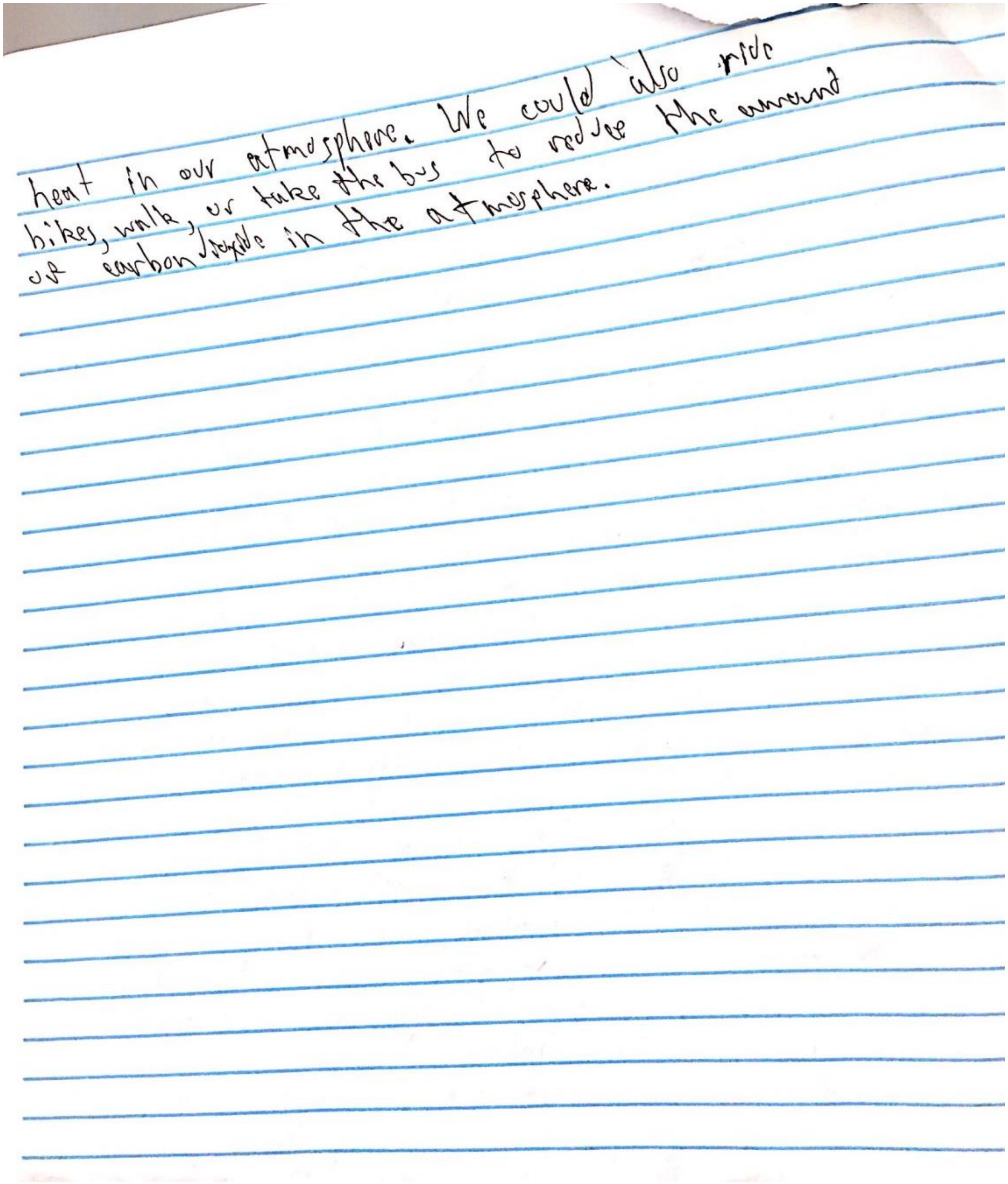
Physics

-- PSA --

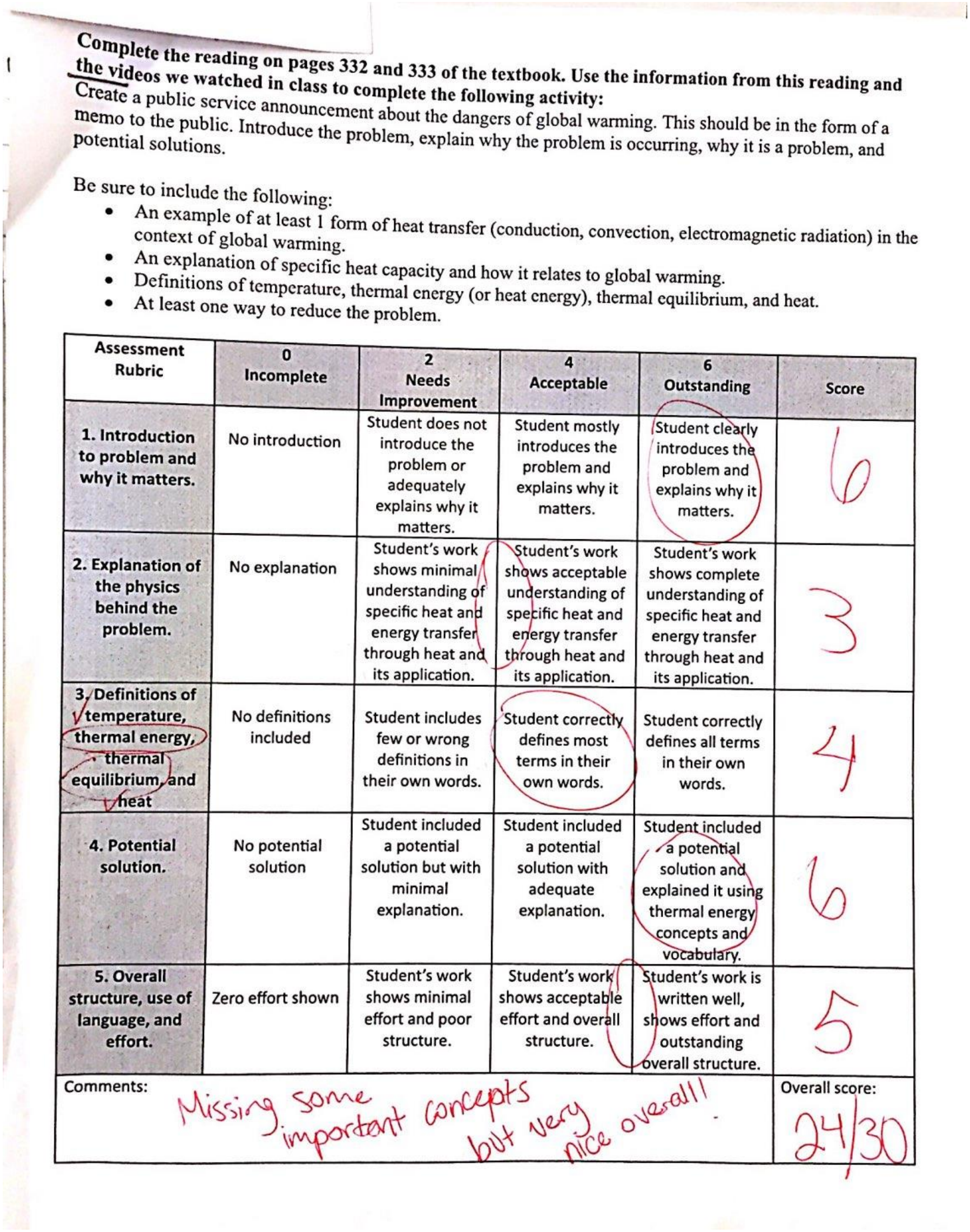
This is a public service announcement to anyone who cares about the future generations of our kids. Global warming is a real threat, and we must adress the causes of it. If we don't stop it then the ice in the polar regions will melt. This will cause flooding, and other natural disasters like mud slides.

To adress this problem we first must know the causes. One cause of Global Warming is the green house effect. This is caused by increased carbon dioxid in our atmosphere. The rise in CO_2 is from cutting down so many trees, witch lowers the oxygen production, and slows down the decrease of CO_2 because less trees are doing photosyntisis because they're dead. Thus increasing the temperature, or degree of heat of Earth. In case those of you who are reading this don't know what heat is, it's the amount of associated movement of energy.

There are ways we the people can do to prevent this from getting worse. For example we should start to replant more of the trees that we cut down. This will reduce the amount of carbon dioxide in the atmosphere. Thus reducing the amount of atoms being heated up by the sun. This will lower the →



heat in our atmosphere. We could also ride bikes, walk, or take the bus to reduce the amount of carbon dioxide in the atmosphere.



Complete the reading on pages 332 and 333 of the textbook. Use the information from this reading and the videos we watched in class to complete the following activity:

Create a public service announcement about the dangers of global warming. This should be in the form of a memo to the public. Introduce the problem, explain why the problem is occurring, why it is a problem, and potential solutions.

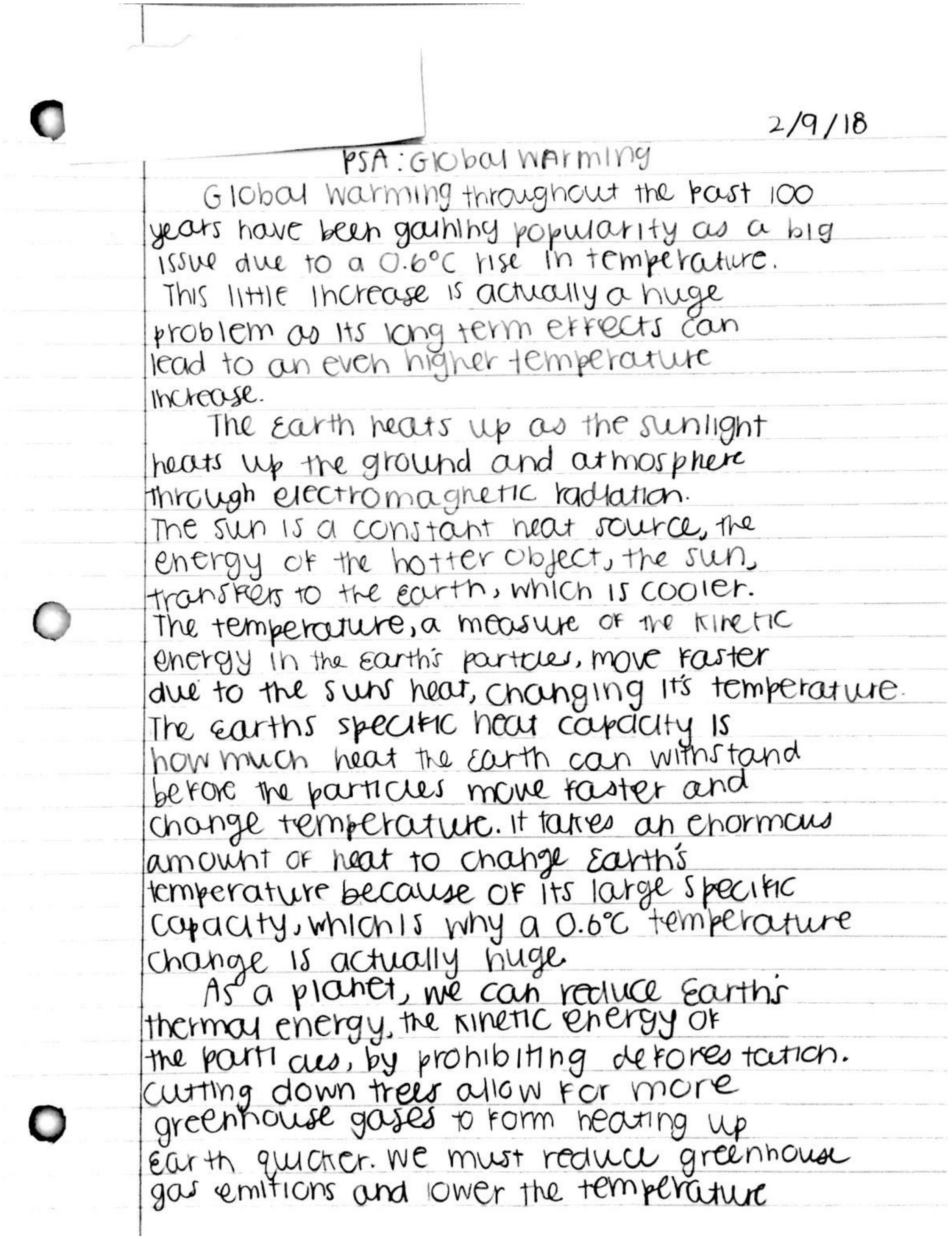
Be sure to include the following:

- An example of at least 1 form of heat transfer (conduction, convection, electromagnetic radiation) in the context of global warming.
- An explanation of specific heat capacity and how it relates to global warming.
- Definitions of temperature, thermal energy (or heat energy), thermal equilibrium, and heat.
- At least one way to reduce the problem.

Assessment Rubric	0 Incomplete	2 Needs Improvement	4 Acceptable	6 Outstanding	Score
1. Introduction to problem and why it matters.	No introduction	Student does not introduce the problem or adequately explains why it matters.	Student mostly introduces the problem and explains why it matters.	[✓ Student clearly introduces the problem and explains why it matters.]	6
2. Explanation of the physics behind the problem.	No explanation	Student's work shows minimal understanding of specific heat and energy transfer through heat and its application.	Student's work shows acceptable understanding of specific heat and energy transfer through heat and its application.	Student's work shows complete understanding of specific heat and energy transfer through heat and its application.	3
3. Definitions of ✓temperature, thermal energy, thermal equilibrium, and ✓heat	No definitions included	Student includes few or wrong definitions in their own words.	[✓ Student correctly defines most terms in their own words.]	Student correctly defines all terms in their own words.	4
4. Potential solution.	No potential solution	Student included a potential solution but with minimal explanation.	Student included a potential solution with adequate explanation.	[✓ Student included a potential solution and explained it using thermal energy concepts and vocabulary.]	6
5. Overall structure, use of language, and effort.	Zero effort shown	Student's work shows minimal effort and poor structure.	Student's work shows acceptable effort and overall structure.	Student's work is written well, shows effort and outstanding overall structure.	5
Comments: Missing some important concepts but very nice overall!					Overall score: 24/30

Appendix O: Exemplary Alternative Assessment

Page 1 of 3



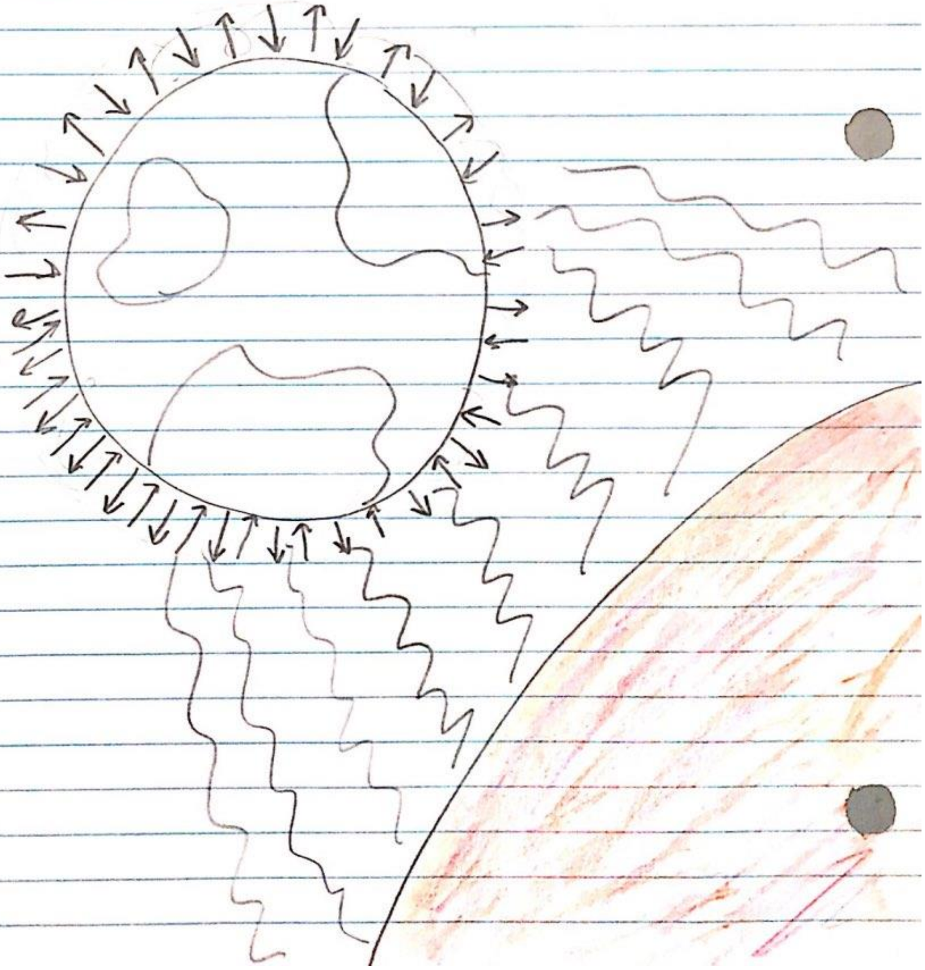
2/9/18

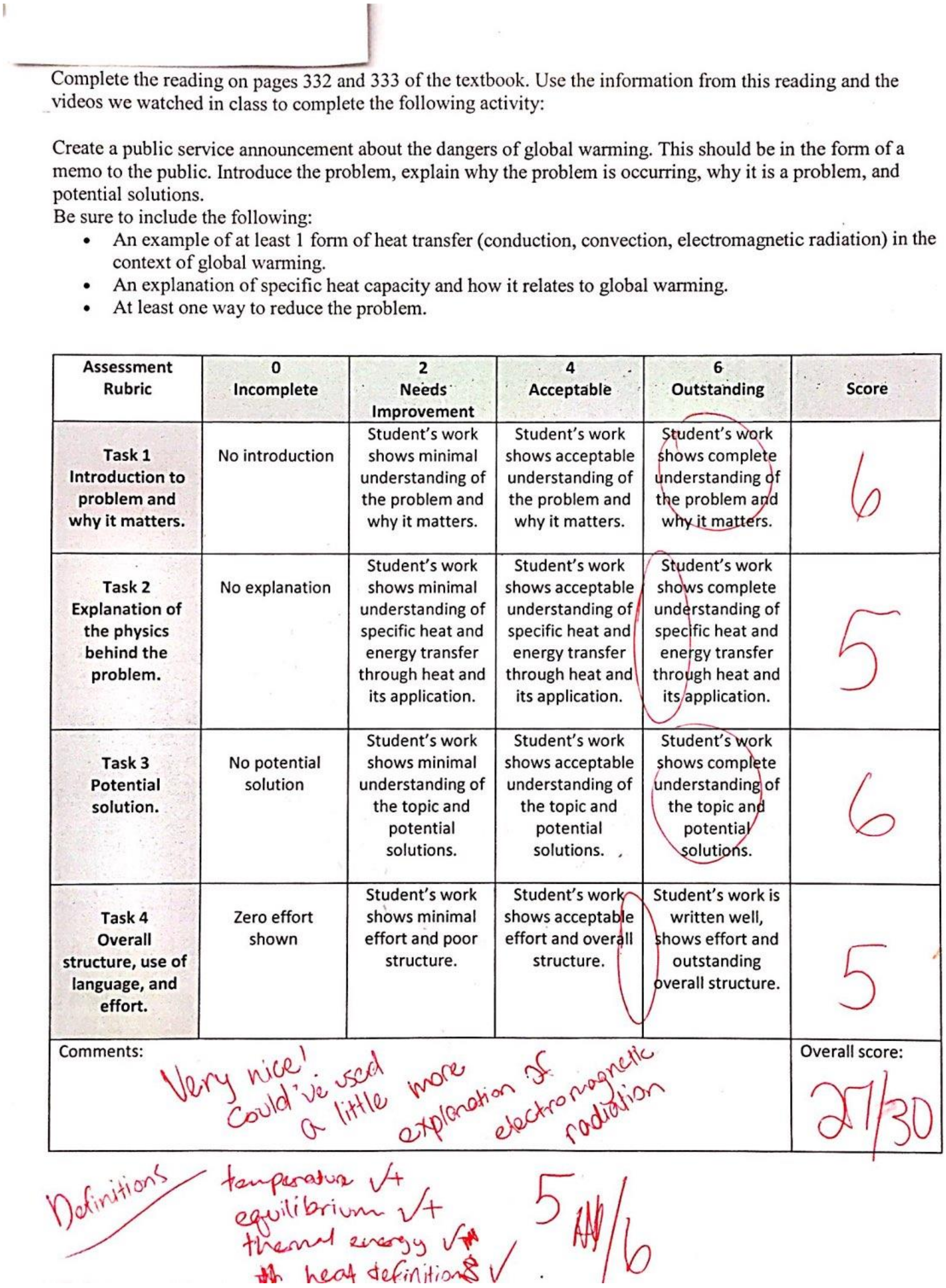
PSA: Global Warming

Global Warming throughout the past 100 years have been gaining popularity as a big issue due to a 0.6°C rise in temperature. This little increase is actually a huge problem as its long term effects can lead to an even higher temperature increase.

The Earth heats up as the sunlight heats up the ground and atmosphere through electromagnetic radiation. The sun is a constant heat source, the energy of the hotter object, the sun, transfers to the earth, which is cooler. The temperature, a measure of the kinetic energy in the earth's particles, move faster due to the suns heat, changing it's temperature. The earths specific heat capacity is how much heat the earth can withstand before the particles move faster and change temperature. It takes an enormous amount of heat to change Earth's temperature because of its large specific capacity, which is why a 0.6°C temperature change is actually huge.

As a planet, we can reduce Earth's thermal energy, the kinetic energy of the particles, by prohibiting deforestation. Cutting down trees allow for more greenhouse gases to form heating up Earth quicker. We must reduce greenhouse gas emitions and lower the temperature because the earth will always continue to heat up. The sun and earth are always going to try and find thermal equilibrium, where these two objects try to have identical temperatures, so we must take actions to help slow this heating of our planet.





Complete the reading on pages 332 and 333 of the textbook. Use the information from this reading and the videos we watched in class to complete the following activity:

Create a public service announcement about the dangers of global warming. This should be in the form of a memo to the public. Introduce the problem, explain why the problem is occurring, why it is a problem, and potential solutions.
Be sure to include the following:

- An example of at least 1 form of heat transfer (conduction, convection, electromagnetic radiation) in the context of global warming.
- An explanation of specific heat capacity and how it relates to global warming.
- At least one way to reduce the problem.

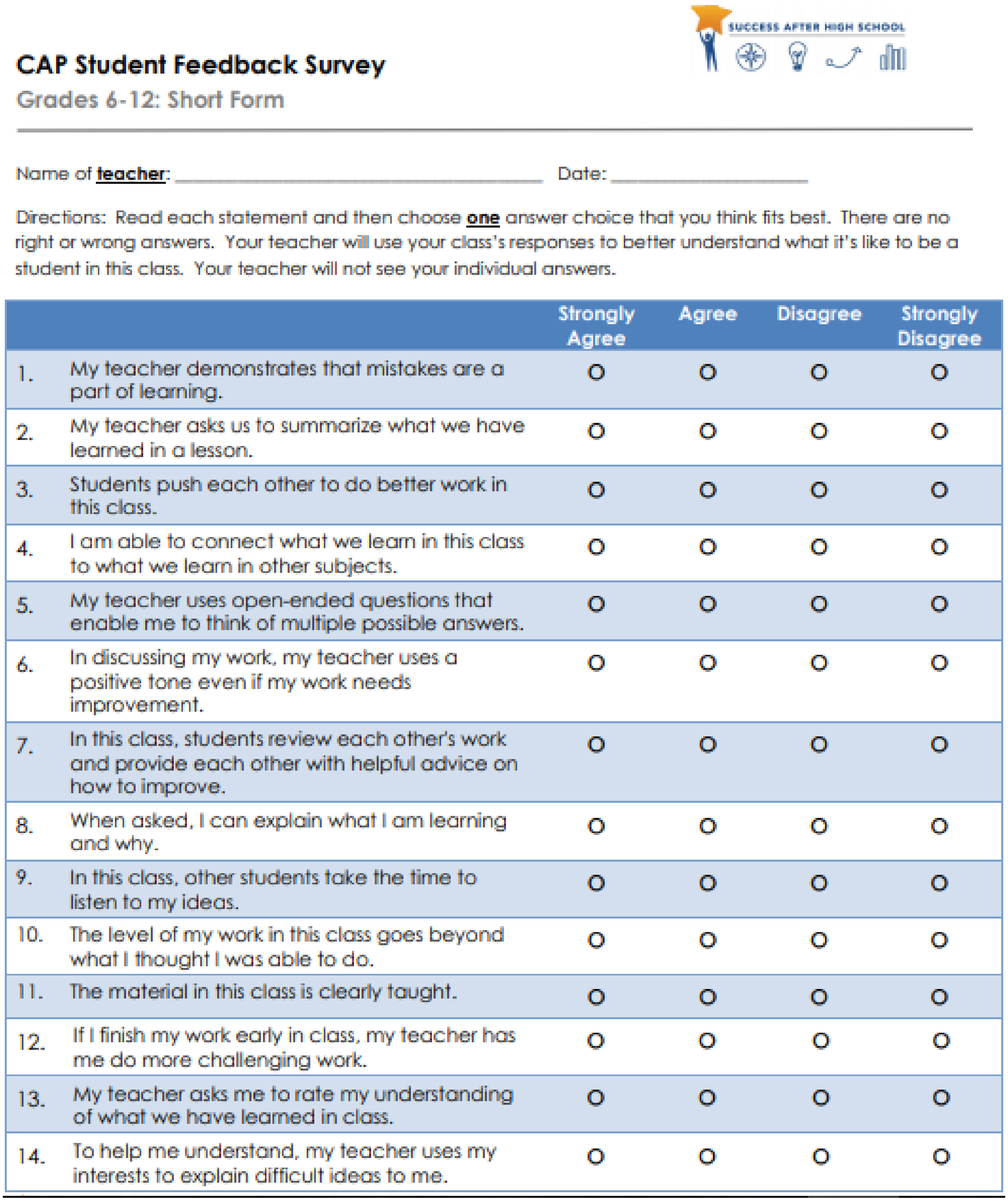
Assessment Rubric	0 Incomplete	2 Needs Improvement	4 Acceptable	6 Outstanding	Score
Task 1 Introduction to problem and why it matters.	No introduction	Student's work shows minimal understanding of the problem and why it matters.	Student's work shows acceptable understanding of the problem and why it matters.	Student's work shows complete understanding of the problem and why it matters.	6
Task 2 Explanation of the physics behind the problem.	No explanation	Student's work shows minimal understanding of specific heat and energy transfer through heat and its application.	Student's work shows acceptable understanding of specific heat and energy transfer through heat and its application.	Student's work shows complete understanding of specific heat and energy transfer through heat and its application.	5
Task 3 Potential solution.	No potential solution	Student's work shows minimal understanding of the topic and potential solutions.	Student's work shows acceptable understanding of the topic and potential solutions.	Student's work shows complete understanding of the topic and potential solutions.	6
Task 4 Overall structure, use of language, and effort.	Zero effort shown	Student's work shows minimal effort and poor structure.	Student's work shows acceptable effort and overall structure.	Student's work is written well, shows effort and outstanding overall structure.	5
Comments: Very nice! Could've used a little more explanation of electromagnetic radiation					Overall score: 27/30

Definitions
temperature ✓+
equilibrium ✓+
thermal energy ✓+
heat definitions ✓

5/6

Appendix P: Student Feedback Survey

Page 1 of 2



SUCCESS AFTER HIGH SCHOOL

CAP Student Feedback Survey

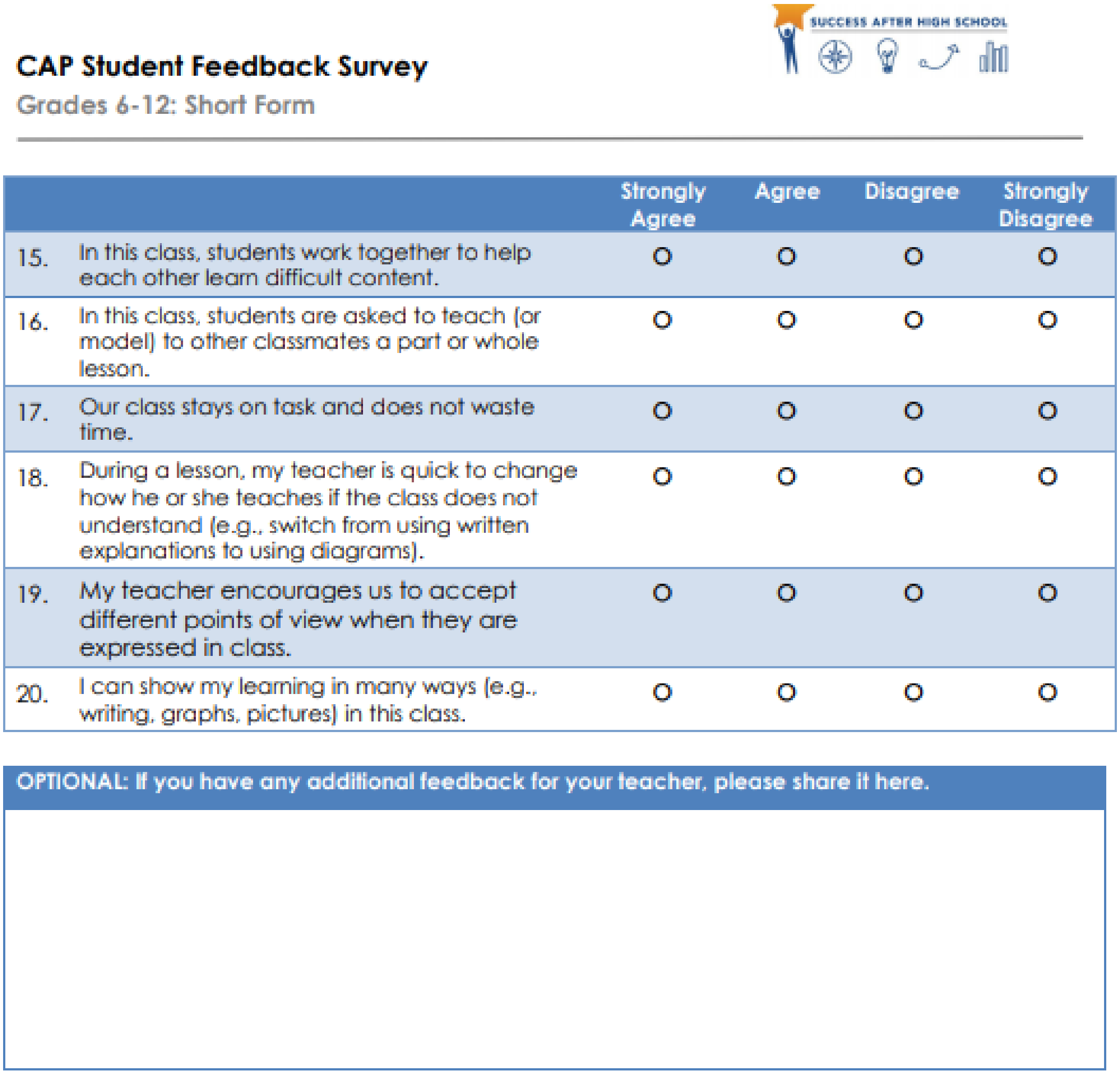
Grades 6-12: Short Form

Name of **teacher**: ______________________ Date: ______________

Directions: Read each statement and then choose **one** answer choice that you think fits best. There are no right or wrong answers. Your teacher will use your class's responses to better understand what it's like to be a student in this class. Your teacher will not see your individual answers.

		Strongly Agree	Agree	Disagree	Strongly Disagree
1.	My teacher demonstrates that mistakes are a part of learning.	○	○	○	○
2.	My teacher asks us to summarize what we have learned in a lesson.	○	○	○	○
3.	Students push each other to do better work in this class.	○	○	○	○
4.	I am able to connect what we learn in this class to what we learn in other subjects.	○	○	○	○
5.	My teacher uses open-ended questions that enable me to think of multiple possible answers.	○	○	○	○
6.	In discussing my work, my teacher uses a positive tone even if my work needs improvement.	○	○	○	○
7.	In this class, students review each other's work and provide each other with helpful advice on how to improve.	○	○	○	○
8.	When asked, I can explain what I am learning and why.	○	○	○	○
9.	In this class, other students take the time to listen to my ideas.	○	○	○	○
10.	The level of my work in this class goes beyond what I thought I was able to do.	○	○	○	○
11.	The material in this class is clearly taught.	○	○	○	○
12.	If I finish my work early in class, my teacher has me do more challenging work.	○	○	○	○
13.	My teacher asks me to rate my understanding of what we have learned in class.	○	○	○	○
14.	To help me understand, my teacher uses my interests to explain difficult ideas to me.	○	○	○	○

Page 2 of 2



SUCCESS AFTER HIGH SCHOOL

CAP Student Feedback Survey

Grades 6-12: Short Form

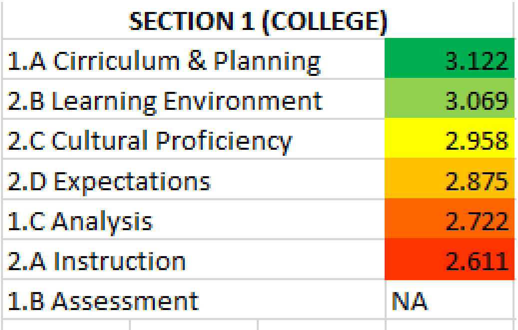
		Strongly Agree	Agree	Disagree	Strongly Disagree
15.	In this class, students work together to help each other learn difficult content.	○	○	○	○
16.	In this class, students are asked to teach (or model) to other classmates a part or whole lesson.	○	○	○	○
17.	Our class stays on task and does not waste time.	○	○	○	○
18.	During a lesson, my teacher is quick to change how he or she teaches if the class does not understand (e.g., switch from using written explanations to using diagrams).	○	○	○	○
19.	My teacher encourages us to accept different points of view when they are expressed in class.	○	○	○	○
20.	I can show my learning in many ways (e.g., writing, graphs, pictures) in this class.	○	○	○	○

OPTIONAL: If you have any additional feedback for your teacher, please share it here.

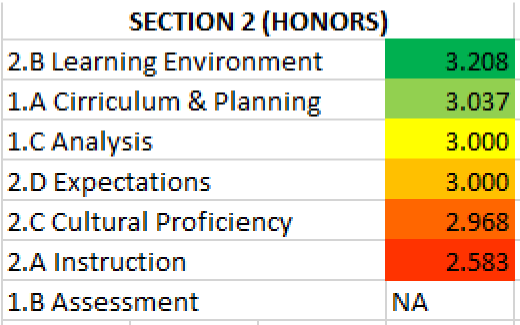
Appendix Q: Student Feedback Survey Data

Page 1 of 1

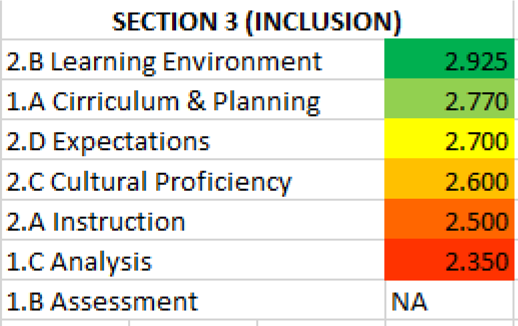
		Needed Improvements
Key:		🟩 Fewest
		🟩
Strongly Agree	4	🟨
Agree	3	🟧
Disagree	2	🟧
Strongly Disagree	1	🟥 Most



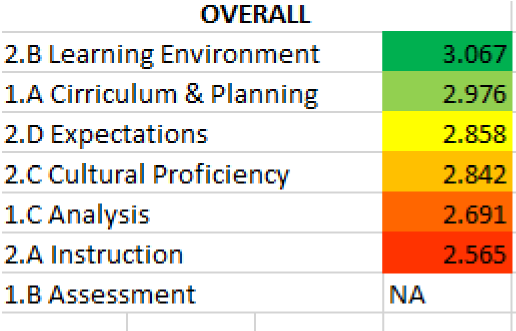
SECTION 1 (COLLEGE)	
1.A Cirriculum & Planning	3.122
2.B Learning Environment	3.069
2.C Cultural Proficiency	2.958
2.D Expectations	2.875
1.C Analysis	2.722
2.A Instruction	2.611
1.B Assessment	NA



SECTION 2 (HONORS)	
2.B Learning Environment	3.208
1.A Cirriculum & Planning	3.037
1.C Analysis	3.000
2.D Expectations	3.000
2.C Cultural Proficiency	2.968
2.A Instruction	2.583
1.B Assessment	NA



SECTION 3 (INCLUSION)	
2.B Learning Environment	2.925
1.A Cirriculum & Planning	2.770
2.D Expectations	2.700
2.C Cultural Proficiency	2.600
2.A Instruction	2.500
1.C Analysis	2.350
1.B Assessment	NA



OVERALL	
2.B Learning Environment	3.067
1.A Cirriculum & Planning	2.976
2.D Expectations	2.858
2.C Cultural Proficiency	2.842
1.C Analysis	2.691
2.A Instruction	2.565
1.B Assessment	NA