

THE EFFECTS OF PERSONAL RESPONSE SYSTEMS  
ON STUDENT ENGAGEMENT AND PERFORMANCE ON TESTS

by

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TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND .....1

CONCEPTUAL FRAMEWORK.....3

METHODOLOGY .....9

DATA AND ANALYSIS .....12

INTERPRETATION AND CONCLUSION .....18

VALUE .....21

REFERENCES CITED.....23

APPENDICES .....25

    APPENDIX A: Montana State University’s Institutional Review Board .....26

    APPENDIX B: Teacher Made Questions .....28

    APPENDIX C: Observations .....31

    APPENDIX D: One-minute Questionnaire .....33

    APPENDIX E: Student Interview Questions.....35

    APPENDIX F: Main Questionnaire.....37

    APPENDIX G: Semester Exam.....39

LIST OF TABLES

1. Data Triangulation Matrix.....12

LIST OF FIGURES

1. Semester Exam Scores for Clicker and Non-clicker users .....13

2. Impact of PRS on Course Grades .....14

3. Student Ratings on Advantages of Using Clickers during Semester 1 .....15

4. Student Ratings on Disadvantages of Using Clickers during Semester 1 .....16

5. Student Interviews Regarding Use of Clickers in the Classroom.....17

6. Student On-line Survey Responses Regarding Use of Clickers .....18

7. Summary of Findings from Fall Semester Regarding Use of Clickers in Class.....20

## ABSTRACT

A growing number of classrooms are using Personal Response Systems, or clickers, to enhance instruction in the classroom. This paper examines the effects of using clickers on student academic performance as well as evaluating student's perspectives on the use of these devices in the classrooms. Thirty-two students were surveyed in two college preparatory physics classes over two semesters. The fall semester students used the clickers while the spring semester students did not... Result showed that student interest and confidence in the material presented seemed greater with the use of these devices. This increased confidence however did not correlate with higher test scores results showed that, 33% of students using clickers scored an A or B on semester exams while 43% did so without the use of clickers. In conclusion clickers did not seem to improve academic success in the classroom and may be used to encourage student participation in the classroom

## INTRODUCTION AND BACKGROUND

Conrad Weiser High School is a suburban school district in the town of Robeson, Pennsylvania. It is located 30 miles west of Philadelphia. The community is comprised of 25% farmers and is also situated just north of Lancaster County which is why it is not that unusual to see an Amish horse and buggy on your way into work. The community is 97 % white with 52 % male and 48 % female (Informatics, 2011). Conrad Weiser High School enrolled 1025 students in 2011. The faculty to student ratio is 15:1. Eighty-four % of the population of the school is Caucasian. Of those students enrolled, 10.7 % are below the poverty rate and 25 % of all students enrolled have Free and Reduced lunches. Robeson has a population of 2,070 people, an average income of 46,751 dollars per household, and the median age of the people is 40.9 years (Informatics, 2011).

The purpose of this research was to examine student perspectives on using Personal Response Systems, or *clickers*, and whether their use correlated with improved test performance. Clickers (PRS) are hand-held remote-control devices that allow students to anonymously answer questions. The responses can then be used to provide feedback on a variety of measures. They work via two frequencies. The infra-red models have a limited range allowing up to 100 students access at any one time. The radio frequency versions are far more advanced allowing up to 1000 plus students to access the software at any one time (King & Robinson, 2009). The most popular vendors are currently: Classroom Response Systems by eInstruction, Inc, Turning Point, Interwrite and Educlick. Each system utilizes a software program that analyzes a frequency input

from a 'response pad'. All products require online registration and many vendors offer additional features such as grade book, attendance, participation monitors, recorded answers to quizzes and exams, and the ability for teachers to generate reports on classroom activity (DeBourgh, 2007).

The clicker's biggest impact was to encourage active learning, cooperation among peers and, provided prompt feedback to the students. However, in order to assess their true academic benefits it is important to examine whether student's positive perception on the use of clickers correlated with improved classroom performance.

Over the course of a full academic year thirty-two students drawn from two college preparatory physics courses participated in this study. Total students enrolled in the classes were 65. Sixty-nine percent of the students were seniors and 55% were females of total students enrolled. Approximately 50% of the total students enrolled were selected for this study. Of students selected 56% ( $N=18$ ) of the sample were given a response pad to directly communicate with the teacher's laptop. Each student had to login using a unique identifier and their attendance and participation were recorded on the teachers computer screen.

The importance of understanding materials taught in my course is very important to me as with all of my colleagues. Hence, I am always looking for tools to use in my classroom that enhance student understanding of content taught within my discipline. In the past, these tools have included the following: cooperative learning, directed reading, demonstrations, power points, The Mechanical Universe and Beyond, Pasco software, laptops, portfolios, lab notebooks, Promethean board, etc. Each has had some impact on

my classroom in regards to comprehension of taught material. In this paper I examine the effects of a new technology that boasts claims of increasing student understanding of materials taught by increasing interests in the classroom. The devices are known as Personal Response Systems or more commonly referred to as clickers. These devices allow students to answer questions presented in class anonymously. The idea is that when students can engage in the course content without fear of public embarrassment they will be more involved and come to better understand the material taught in the classroom. This paper will examine if that claim is true by answering the question “Do clickers help improve student comprehension by increasing student participation and active engagement in my classroom?”

#### CONCEPTUAL FRAMEWORK

Teachers have long strived to develop methods to actively engage students in learning (DeBorough, 2007). Large classroom sizes often cause teachers to struggle with methods to keep students from being distracted and unmotivated (King & Robinson, 2009). In critical subjects such as math and sciences keeping students engaged is critical. Increased reliance on technology has become a common tool to achieve that goal. Personal Response Systems (PRSs), *clickers*, have been proposed as a tool teachers can use in the classroom to help improve student participation and engagement in active learning. The hope is that these devices would correlate with improved retention of material presented and improved test scores.

Research has shown that students enjoy using Clickers. Students have reported that clicker use helps maintain student attention during class, creates a way for shy

students to participate, and can promote discussion and collaboration. (Boatright-Horowitz, 2007).

Analysis of research on the use of clickers showed that PRSs were used to introduce questions related to concepts learned in the classroom. One research study reviewed, used three or four questions which were provided after a lecture. Students anonymously answered the questions using the clickers. Upon answering those questions, teachers encouraged a peer-led discussion of the results generated by the clicker software. Eventually, students were given quizzes and exams on material presented. . The scores of these exams were then examined to see if there were any benefits to using this new technology. (King & Robinson, 2009) The Generative Theory of Learning states that students learn better when they engage in active cognitive processing during learning. Active cognitive processing can occur in three different stages. First students must be more attentive to lecture material. Secondly students must learn to work harder to organize and integrate the material presented. Finally, after feedback from the teacher, students may develop metacognitive skills for gauging how well they understood the lecture material and how to answer exam-like questions (Mayer, et al., 2009).

One effective way of achieving those goals would be through effective questioning techniques. The use of focused questioning is a powerful method to provide feedback to students (DeBourgh, 2007). Using questioning encourages student preparation for class, enhances active participation and can result in higher academic achievement. This academic tool can also shift student's focus of classroom instruction from straight recall to active reasoning. Encouraging students towards critical thinking,

encourages intellectual exercises to draw conclusions, form judgments, and make inferences based on evidence, material presented and classroom experience. In essence, questioning leads to higher level cognitive processing. The best questioning techniques to foster learning include: having students answer adjunct questions while reading a text, taking practice tests, and explaining concepts aloud as they read a textbook lesson (Mayer, et al.,2009). Along with using tactical questioning, participation and feedback are essential to the learning process. Students who do not prepare by completing assigned readings or homework tend to disengage and become inattentive during a lecture. This can have adverse effects on the students' academic achievements. This can also occur in the classroom in which students are reluctant to participate. Classroom communication apprehension is a term used to describe students who sit back and avoid involvement in the classroom. The lack of participation can often cause adverse results regarding their success in the classroom. Lack of participation by students can decrease the teacher's ability to respond to student feedback which can be a powerful tool to improve the classroom environment (DeBourgh, 2007).

It is now believed that clickers, along with high-level questions strategically placed throughout instruction, can enhance participation and feedback, even in very large classrooms. It is believed that clickers promote: (a) greater student engagement, (b) improved student participation, (c) increased understanding of material, (d) higher levels of enjoyment, (e) improved group interaction, (f) tool to gauge understanding, and (g) better recognition by teachers of issues that may impact learning in the classroom. These

are all outcomes that could promote active cognitive processing and have a positive effect on academic achievement. (DeBourgh, 2007)

In regards to student opinions on clickers regarding learning, student engagement and positive perceptions, many articles showed favorable results. In one study (Boatright-Horowitz, 2007), 62% of responders reported favorable opinions regarding the use of clickers in regards to student comfort, confidence, attitude change, mastery of content and student retention. The same survey had students ranking personal participation high even in classes where enrollment exceeded 700 students. In a study (King & Robinson, 2009) of undergrad engineering students from Loughborough University, opinions on learning, engagement and impact on students' academic achievement found that 80% of students found the handsets useful ( $N=145$ ). Of those students, 105 students said the clickers increased participation rates. The author used observations, one-minute papers and informal feedback to assess student perceptions of clickers on participation. Though the impact on student retention was minimal, it was clear from student comments that use of such technology in the classroom was perceived as beneficial. One student stated, "Let's you know how well you are understanding the material as it's taught (King & Robinson, 2009, p.194). Another student stated, "Shows where I need to work more" (King & Robinson, 2009, p.194). In another study 10,011 students were surveyed with 3,697 responding. Of the respondents 56.4% of the students rated favorably the use of clickers. Students were more likely to rate the use of clickers positively when the teacher encourages discussion amongst peers (Keller, et al, 2007). However, in a more

comprehensive study (Perkins and Turpen, 2009) the researchers found only a slightly positive effect regarding feedback (29%) and engagement (23%).

In evaluation of the effects clickers have on student performance and grades, multiple studies have sought to examine the effects on grade performance as a result of using clickers. One study involved students enrolled in the University of Wisconsin's accounting class who were asked to answer nine related multiple choice exam questions (Cummings & Hsu, 2007). The dependent variable in this study was the number of correct answers out of nine. The independent variable was GPA and whether a clicker was used or not. The four accounting classes were also compared with four universities, 27 faculty and 3500 student's within the Wisconsin inter-university system. This study, focused on exam performance instead of student perceptions. The result did not demonstrate any statistically significant academic performance is students using clickers compared to students that did not use this tool over non-clickers. The two groups did not demonstrate any significant difference in exam scores, however, student GPA was better predictor of better scores on the test and was a more significant predictor of overall exam performance. In a study conducted by Watkins & Sabella, physics students at Chicago State University used clickers to examine student understanding of content learned regarding kinematics and vectors (2008). The study made use of Clicker Question Sequences (CQS) during lecture and placed similar questions on the subsequent exam. In regards to the kinematics unit, students scored 33% on twelve exam questions even after those questions were answered with clickers prior to taking the exam. Similar results were found regarding vectors where the average score was 42% on another 12 exams.

Interestingly, using the CQSs during lectures, students scored a 94% or better on the final question after lecture material presented. However, on the exam they did poorly on same questions in multiple choice formats. The lone study that showed a significantly higher score on their course exams was the one conducted at UC, Santa Barbara (Mayer, et al, 2009). The study looked at approximately 385 students enrolled in a Psychology 124 course. The study occurred over three semesters from 2004 through 2007. The population was 75% female with 99 % being seniors and juniors with an average SAT score of 1167. Three groups were compared. In the first group clickers were used to answer two to four questions per lecture. This was compared with a non-clicker group ( $d=0.38$ ) and another group (control;  $d=0.40$ ) that had neither clickers nor questions. The clicker group produced a gain of one-third of a grade point over the no-clicker and control groups. Neither of the latter two groups had much gains over the other. These results are consistent with the generative theory of learning. It supports the hypothesis that the clicker group will be more actively engaged in learning and therefore will retain more material and improve test scores.

Research has shown that clickers can support innovative instructional designs and the delivery of active cognitive processing skills in the classroom. Combined with tactical questioning techniques and dynamic learning, clickers can improve the learning environment in the classroom (Lantz, 2010). This can have the effect of increasing student engagement, participation, comfort, content mastery, collaboration and student-teacher interaction.

Other conflicting studies have questioned whether the use of clickers improve student learning. Student performance on post-examinations after using clickers during lectures combined with peer discussion often has not yielded statistically significant improvement in learning. (Watkins & Sabella, 2008). More research needs to be done in order to examine why there often appears to be conflicting evidence on the benefits of the use of clickers. The long term effects on learning by the use of clickers is still to be determined. Until more data can be collected and further research is conducted one cannot conclude that using clickers will lead to improved academic performance. However, with the positive perceptions students express on the use of clickers and the resultant increased student participation in the classroom, one hopes that this will eventually correlate with improved academic success.

#### METHODOLOGY

The treatment of this study consisted of data collected from students when using clickers in fall (N=18) and subsequently when clickers were not used in the spring (N=14). In each semester the instructor was the same and no difference was noted among either group based on their GPAs, PSAT scores, and course load. The course content and semester exam was the same in both cases and the method of instructional delivery was the same except for the use of clickers in the fall group. In the fall group each student received a device with a specific code. After an introduction to the clickers, students were asked two to three questions per class period. In the spring semester, students were not given clickers. The study examined the results over two semesters. At the end of each semester, an exam was administered to the students as well as a main questionnaire. The

research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Students drawn from two college preparatory physics courses during the 2012-2013 school year participated in this study. The total cohort size was 32 students. Sixty-nine percent of the students selected were seniors with 55% being female students. Though only a small percentage of the total student population was selected for this study, all pupils were given a response pad to communicate with the teacher's laptop. Each student had to login and their attendance and participation was recorded.

Multiple choice questions test were developed to evaluate students comprehension of material presented. Each lesson consisted of two to three PowerPoint slides for each of the chosen lectures (Appendix B). Each slide contained a multiple choice question that reviewed or identified misconceptions that covered a portion of the lecture content or a question that addressed problem solving and was mathematical in nature. The clicker questions were not used on the exam but scores were tabulated, recorded and saved up until the final exams. The exams were created by the teacher and were similar to the questions used in the lecture (Appendix B).

The use of clickers allowed the teacher to be a passive observer throughout the semester and aided in observing the students in action in the classroom. The observations were open-ended and included general observations of student's behavior that was recorded in teacher journals. Observations recorded included real data such as quantity,

time, and purpose of questions used, as well as assessing student responses and enthusiasm (Appendix C).

Students were allowed 120 seconds to complete an open-ended questionnaire (Appendix D). This questionnaire specifically asked students to list the pros and cons of using personal response systems in the classroom. This instrument was used to analyze what students thought about the use of clickers in the classroom.

Students were interviewed using Student Interview Questions to collect more in depth data on their perceptions of the effect using clickers had on their understanding of course material. Data collection began with a more informal feedback/discussion with the students which took place immediately following classes where the clickers had been used. These questions included subjective responses on student's perceptions of the use of clickers (Appendix E). This was followed up with more formal interviews on a smaller percentage of the 32 student participants in this study.

To further investigate this topic, the 18 students in the fall who participated in this study were asked to complete a 10-item questionnaire regarding the use of clickers in the classroom (Appendix F). The survey assured confidentiality and students were assured answers would not affect student grades.

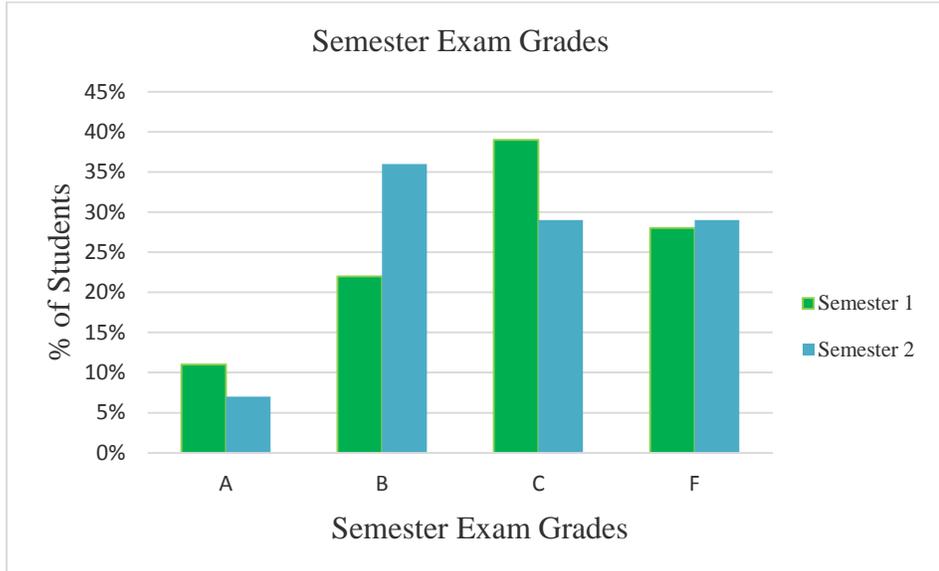
A final exam was created by the instructor to evaluate the effects of clicker use in the classroom on grade performance (Appendix G). Each test contained 35 questions with 25 being very similar to the question used during the PRS sessions.

Table 1  
*Data Triangulation Matrix*

Research Questions	Data Source 1	Data Source 2	Data Source 3
Feedback using clickers?	Student Interviews	Observations	
Do clickers help apply concepts?	Teacher-generated test	Course grades	
Prefer traditional vs clickers in the classroom?	On-line survey	Interviews	Survey
Did clickers better prepare you for class?	One-minute questionnaire		
Did clickers help you do better on quizzes/exams?	Teacher-generated tests	On-Line Survey	Interviews

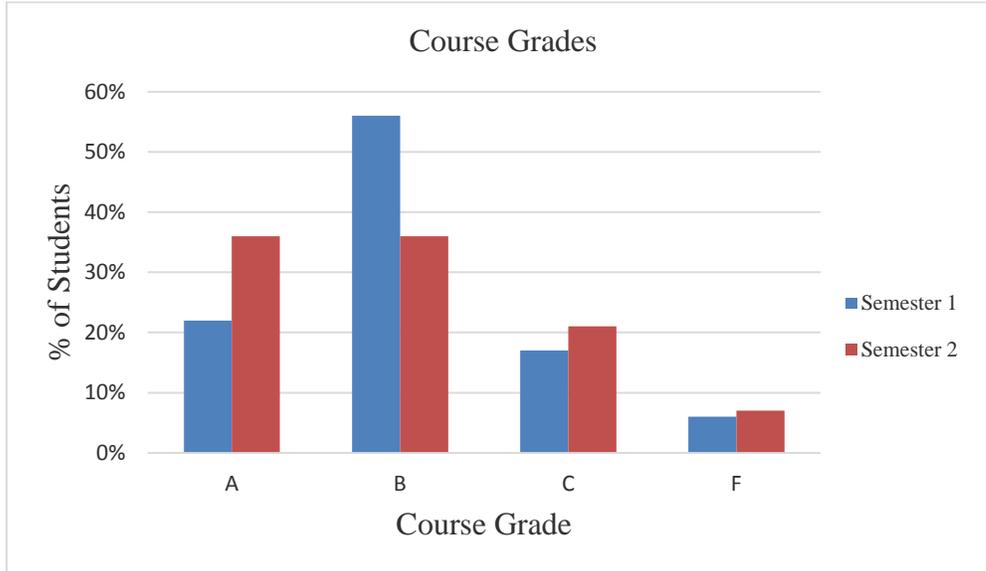
## DATA AND ANALYSIS

The student's grades on the Semester Exams in both groups were compared ( $N = 32$ ). Responses gathered from the Semester Exam showed a higher percentage of students scoring an A or B on the exam (43%) not using clickers as compared with those who scored an A or B on the exam (34%) when using clickers (Appendix G). However, the clicker group had a higher percentage (12%) who achieved a grade of A on the Semester Exam compared with the spring semester in which only 7% scored an A. Overall, each group had approximately the same percentage of students who passed the exam with the clicker group having 73% pass and 71% in the non-clicker group. In figure 2 below, the results for final course grades are examined in regards to the clicker (semester 1) and non-clicker (semester 2) group. The results are shown in Figure 1.



*Figure 1.* Semester Exam Scores for clicker (Semester 1) and non-clicker (Semester 2) users, ( $N=32$ ).

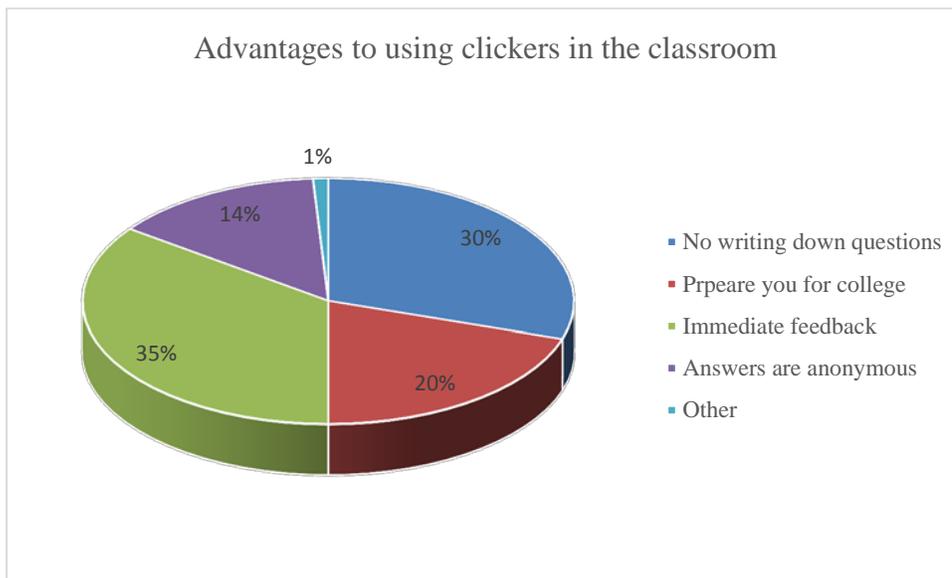
The clicker group had a higher percentage (77%) of students who scored an A or B for the course as compared with the non-clicker group who had 71% of the students achieve the same. However, the non-clicker group experienced a slightly higher percentage (21%) of students who scored a C grade for the course as compared with the clicker group in which 17% of the class scored a C grade for the course. In either group, as was the case with semester exam scores, both groups had approximately the same percentage of students who received a grade of C or higher with 94% passing the course in semester 1 and 91% passing during semester 2. This is illustrated in Figure 2 below.



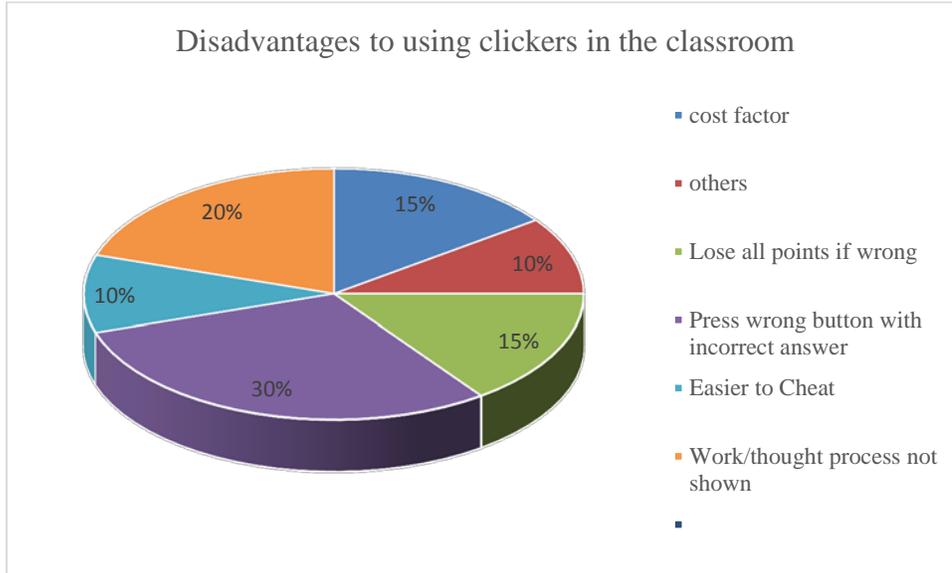
*Figure 2.* Course Grades for clicker (Semester 1) and non-clicker (Semester 2) users, ( $N=32$ ).

During the Fall Semester, students in the clicker group received a number of end-of-term surveys which examined students' opinions on a variety of aspects of the course which included but not limited to advantages/disadvantages to using clicker questions, exam preparation, classwork, etc. Forty-nine percent of responders surveyed *agreed* that the most beneficial aspects of using clickers was that the users could remain anonymous while receiving immediate feedback concerning the question. Of that percentage, 35% placed a higher emphasis on feedback provided as compared with only 14% that claimed anonymity was the more important factor of using clickers. A percentage (30%) felt that not having to write down the questions was a huge benefit of using the clickers. This response to the survey is a direct reference to the non-clicker group whom had to record questions presented in class. Twenty percent of students felt the use of clickers did help prepare them for college. Forty-five percent of those surveyed were concerned with getting the wrong answer and losing points for that question. In both groups, students

were given a minimal amount of points for a correct answer and no points for an incorrect answer since questions were used as a review source. The survey also showed that students felt the clickers could made it easier to cheat (10%) and students felt that it was unfair that the clickers could not show work/thought process for arriving at an answer (20%). The survey showed a very high percentage (75%) of responders concerned with their grade being affected by using the clickers. These advantages and disadvantages to using the clickers are shown in Figure 3 and 4 below.



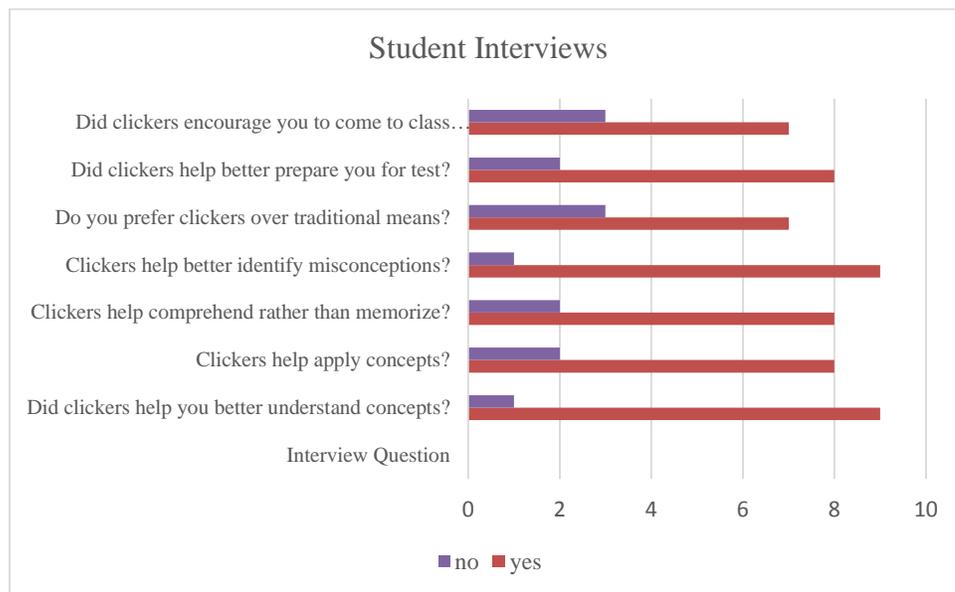
*Figure 3.* Student ratings on advantages of using clickers in the classroom during Semester 1, ( $N=18$ ).



*Figure 4.* Student ratings on disadvantages of using clickers in the classroom during Semester 1, ( $N=18$ ).

Ten students from the fall semester (clicker group) were interviewed separately and asked seven questions regarding their use of the clickers in the classroom. The graph shows a high percentage of students confident that the use of clickers helped them in preparation for their semester exams. In particular, when asked the question about clickers helping better prepare you for the test 80% of those interviewed said that the clickers did help them do better on the exam. Likewise, when asked about using the clickers' to help better understand the materials rather than just recognizing correct answers 90% of students interviewed stated that the clickers did help them to better understand the material taught. Reasons stated for the high percentages of students claiming clickers helped them to learn better included, "Immediate feedback allowed me to ask questions to gain further knowledge of the subject material." Another student stated "I felt I understood material better because clickers forced me to understand material." Finally, one student interviewed felt "If I got wrong first time using clickers,

then helped second time when you see similar question on exam.” No one question showed a majority of students stating the clickers had a negative impact, but 30% of students did feel that they prefer traditional instruction over using clickers and that the clickers did not encourage them to come to class better prepared. One student did state that the “clickers were annoying and boring.” This is shown in Figure 5 below.



*Figure 5.* Student interviews regarding use of clickers in the classroom, ( $N=10$ ).

The results of the online survey conducted with the students from the clicker group (Fall Semester) were examined. Of those surveyed 70% or more claimed a positive impact from the clickers in seven out of 10 questions. Ninety-seven percent of students felt that the clicker’s immediate feedback helped their understanding of learned material and 79% claimed that lectures were far more beneficial when using clickers in the classroom. When asked if clickers helped them do better on the exam, 74% of students polled agreed and 70% preferred using clickers rather than traditional means. However, of those same students, 62% felt the clickers had no impact on how prepared they came

to class and 50% felt the devices had no impact on their attending class. This is shown in Figure 6 below.

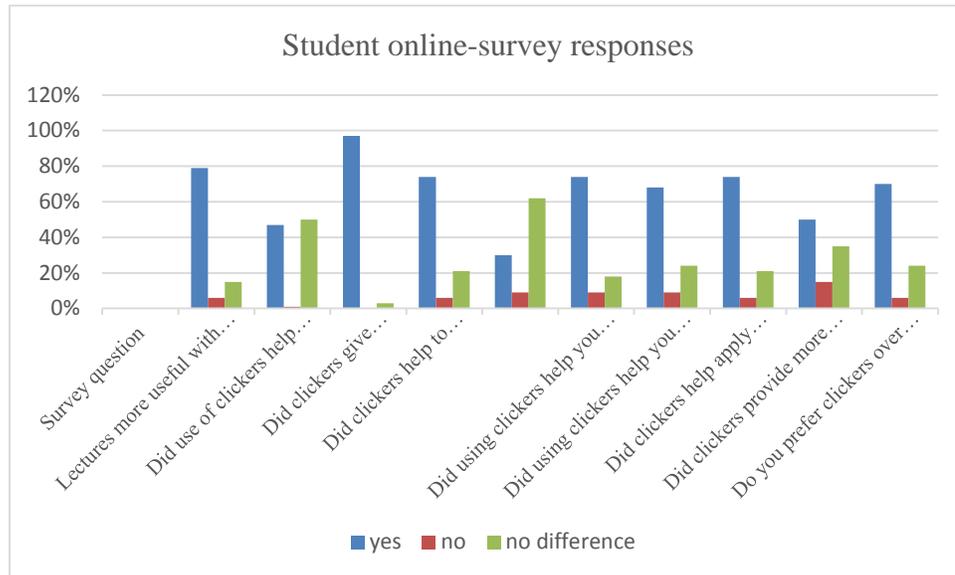


Figure 6. Student on-line survey responses regarding use of clickers in the classroom, (N=18).

## INTERPRETATION AND CONCLUSION

A high percentage of students prefer clickers over traditional means of instruction when preparing for an examination. From the data analysis it is clear that students in the Fall Semester 2013 felt a benefit from using clickers in their classrooms. In each of the four instruments used, a high percentage of students cited clickers as an effective tool in the classroom in regards to test preparation and comprehension. Of those involved in the student interviews, 80% felt that the clickers helped them achieve better scores on the semester exam. Of the four questions that focused on comprehension of learned materials, over 80% of students interviewed said using clickers had a positive impact on their learning. In particular, 90% of those students felt that use of the clickers helped

them to better understand their misconceptions as well as understand the concepts taught during the semester. Another 80% of students in the interviews felt they could better apply concepts learned as well as comprehend the material rather than just memorize the content. Most of the students claimed in the interviews that the immediate feedback the clickers supplied, and the anonymous nature of the responses, were a major contributing factor to improved understanding and comprehension. This is evident in the one-minute questionnaires where 49 % of students reported the main advantage to using the clickers were the immediate feedback and anonymity allowed when answering questions. This was reaffirmed when collecting the end-of-course online surveys in which all questions involving comprehension, understanding, and better scores on exams had over 70% of students polled rating positively the effect of using the clickers in their classroom. From the data collected it is clear that the students who used clickers in the fall semester of 2013 felt a benefit not only in understanding the material learned but in their exam scores as well.

However, there is no evidence to verify student perceptions when it comes to the effectiveness of the clickers in regards to their semester exam grades as well as course grades. In looking at the semester exam grades for the two classes (clicker vs non-clicker groups) both groups had about the same percentage of students pass the semester exam as the other. In the fall semester (clicker group) 72% of group passed the final exam while 71% passed the exam in the spring semester. A greater percentage (36%) from the non-clicker group did score a 'B' on the exam compared with the clicker group (22%), but

12% of the students in the fall did receive an ‘A’ on the exam while only 7% did so in the spring.

The same can be said of the course grades. Based on Figure 2, there is no clear statistical evidence that either group did better for the course whether they used clickers or not. In fact, 95% of students in the fall and 93 % from the spring received a passing grade for the course. This is quite similar to the findings for the semester exam except the percentages were lower for those who passed the semester exam but both groups were nearly identical in how many students passed either the exam or course. The only peculiar piece of data was in the percentage (55%) of those in the fall who scored a ‘B’ for the course as compared with the spring where (35%) achieved a B grade

From the data presented it is clear that the students believe the clickers benefitted them in understanding the concepts taught, comprehending misconceptions, and applying those concepts to other situations. However, there is no evidence that the students perception correlated with actual improvement on test scores and final course grades. These findings are summarized in Figure 7 below.

Student Perspectives	Evidence
80 % felt clickers improved exam scores	Lower % for clicker group received above average* on semester exam grade
80 % agreed... Positive impact	Higher % of clicker group had above average for course grade
Comprehension Apply concepts	Approximately same % passed semester exam & course
Corrected misconceptions	

*Figure 7.* Summary of findings from fall semester regarding use of clickers in the classroom.

## VALUE

This research paper was beneficial in that it allowed me to see the scientific process in action. In education we often throw new ideas or technological tools out into the classroom without ever collecting data to see if there are any benefits to using such tools. I was told from a lot of colleagues that using clickers had a direct benefit in terms of grades and attitude in their own classrooms. I was encouraged by these reports and as a result invested much of my science budget for the 2011-2012 school year in Personal Response Devices. This decision was made without examining existing research pertaining to the use of PRS and whether their use was correlated to improved academic success. This course and the MSSE program provided me an opportunity to put science into action and evaluate whether in my classroom the implementation of the use of clickers improved academic success.

Regardless of the results of my research on whether clickers improve student's comprehension of material I plan to continue to use these devices in my classrooms. I am encouraged by the finding that shows a strong correlation with student perceptions about the clickers and their comprehension of concepts taught, overall enjoyment of the use of clickers, and their preference for using clickers in the classroom over traditional means. As one student stated, "I love the instant feedback and the fact that no one knows it was me who got that wrong. I feel I learn better by seeing choices of answers provided and learning how to navigate through the wrong ones in a timed fashion." It is my belief that the use of clickers can be a helpful tool by encouraging student participation and active

learning in my classroom, regardless of the evidence that shows these devices have no effects on student's grades.

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APPENDICES

APPENDIX A

MONTANA STATE UNIVERSITY'S INSTITUTIONAL REVIEW BOARD



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

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 Cheryl Johnson  
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**MEMORANDUM**

**TO:** Donald Koper  
**FROM:** Mark Quinn, Chair *Mark Quinn CJ*  
**DATE:** December 10, 2011  
**RE:** *Effects of Personal Response Systems on Student Engagement and Performance on Tests*  
 [DK121011-EX]

The above research, described in your submission of December 7, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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

APPENDIX B  
TEACHER MADE QUESTIONS

1. If Boston Red Sox baseball legend, Carl Yastrzemski, hit a baseball due west with a speed of 50.0m/s, and the ball encountered a wind that blew it north at 5.00m/s, what was the resultant velocity of the baseball? (vector)  
A) 50.9 m/s, NE      B) 55.0 m/s, NW      C) 50.2 m/s, NW      D) 45.0m/s, NE
2. Calculate the magnitude of the resultant of a pair of 100 km/h velocity vectors that are at right angles to each other. (vector)  
A) 100 km/h      B) 141 km/h      C) 200 km/h      D) 0 km/h
3. What is the maximum and minimum possible between two vectors of units 11 and 3? (vector)  
A) 14, 8      B) 11.4, 3      C) 11, 3      D) 14, 3
4. The boy on the tower throws a baseball 20 meters down range as shown on the board. What is his pitching (horizontal) speed? (Case V)  
A) 10.0 m/s      B) 20.0 m/s      C) 4.0 m/s      D) 30.0 m/s
5. Larry was spending one swell Sunday afternoon rolling his hot wheels cars off the edge of a table. The table is 1m tall and the toys generally hit the ground 1.2 m from the table. What were the toy cars velocities after they left the table? (Case V)  
A) 2.45 m/s      B) 10.0 m/s      C) 4.50 m/s      D) 2.67 m/s
6. A canon is firing shots from a cliff in the horizontal direction. The shells have an initial velocity of 200m/s in the horizontal direction and they strike the ground 2000m away. How tall is the cliff? (Case V)  
A) 250.0 m      B) 500.0 m      C) 4000.0 m      D) 10.0 m
7. Jonesy the Cat cranks up to throw a snowball at Santa Claus, 124 ft. away. If he throws the snowball at 64ft/s and at an angle of 45.0o, find the range of his arm and if there will be a Christmas this year? (Case VI)  
A) 126 ft      B) 124 ft      C) 63 ft      D) 120 ft.
8. At her wedding, Estefania lines up all the single females in a straight line away from her in preparation for the tossing of the bridal bouquet. She stands Kristinn

at 1.0m, Amanda at 1.5 m, Bryttny at 2.5 m, and Ajia at 3.0 m. Estefania turns around and tosses the bouquet behind her with a speed of 3.9m/s at an angle of 50.0o to the horizontal, and it is caught at the same height 0.60s later. Who catches the bridal bouquet? (Case VI)

A) Kristinn                      B) *Amanda*                      C) Bryttny                      D) Ajia

9. The demonstration in class with the broom and the eggs was used to show inertia. This demonstrated that a(n) (Inertia)

A) *objects at rest want to stay at rest.*                      B) object in motion stays in motion.  
C) eggs fall faster than toilet paper centers.                      D) failed to show anything.

10. A sled slides down a hill and reaches a level surface and eventually comes to a stop. The fact that the sled ultimately stops is best explained by \_\_\_\_\_. (Inertia)

A) the presence of inertia causes it to stop.                      B) the natural tendency of any object is...  
C) an unbalanced force would be required...                      D) *The presence of an unbalanced force...*

APPENDIX C  
OBSERVATIONS

Tally sheet for use Team 3 in use of clickers, Mr. Koper's class

Behaviors/Activities	Bobby	Larry	Harry
Member actively participates.			
Each member is respectful of one another.			
Each member attempts to complete work on their own before asking me questions.			
Each member stays on task.			
Each member submits response in required time limit.			
Member participates in feedback.			
Member selected correct response.			

APPENDIX D  
ONE-MINUTE QUESTIONNAIRE

1. What are the advantages to using 'clickers' in this classroom?
2. What are the disadvantages to using 'clickers' in this classroom?

APPENDIX E  
STUDENT INTERVIEW QUESTIONS

1. Did using clickers give you immediate feedback regarding your understanding of the concept? Provide examples.
2. Did using clickers help you apply the concept during class? Explain with examples.
3. Did using clickers encourage you to really understand the materials rather than just recognizing the correct answer? Provide examples.
4. Did using clickers help you identify misunderstandings and misconceptions in your thinking while in class? Provide examples of each.
5. Do you prefer the more traditional lecture approach rather than the clicker approach? Explain.
6. Did using clickers in class help you do better on quizzes and exams? If no exam is applicable, do you think you will perform better on your next exam?
7. Did using clickers encourage you to come to class better prepared? Why or why not?

APPENDIX F

MAIN QUESTIONNAIRE (ONLINE SURVEY)

Survey created online at...

<http://www.quia.com/sv/550743.html>

APPENDIX G  
SEMESTER EXAM

**PHYSICS SEMESTER EXAM**

**INSTRUCTIONS:** Follow the instructions for each section below. Point values for each section are as marked. You have 90 minutes in which to complete this test. Work carefully, but do not spend too much time on any one question. You may use your notes, textbook, labs and a calculator. There are two sections to this test. Answer all questions from part one on clean loose-leaf. Partial credit will be given. Answer all questions from part two on the scantron. Use a # 2 pencil.

**PART ONE – SHORT ANSWER** (60 points) Answer each question on clean looseleaf. Partial credit will be given. Point values are as marked. Show all work and circle final answer to receive credit. No credit will be given for answers that are not explained. There are fifteen problems below. Good Luck!

**PART TWO – MULTIPLE CHOICE** (40 points) Make sure the number of the question corresponds to the number you fill in on your answer sheet. Select the best answer for each question. Fill the letter of your choice on your answer paper. Use a #2 pencil.

**PART ONE – SHORT ANSWER**

1. The Steamboat Geyser in Yellowstone National Park, Wyoming is capable of shooting its hot water up from the ground with a speed of 48.0 m/s. How high can this geyser shoot?
2. Daniel is standing on a ladder picking apples in his grandfather's orchard. As he pulls each apple off the tree, he tosses it into a basket that sits on the ground 3.0 m below at a horizontal distance of 2.0 m from Daniel. How fast must Daniel throw the apples (horizontally) in order for them to land in the basket?
3. Brittany shovels snow after a storm by exerting a force of 30.0N on her shovel at an angle of  $60.0^\circ$  to the vertical. What are the horizontal and vertical components of the force exerted by Brittany?
4. A popular trick of many physics teachers is to swing a pail of water around in a vertical circle fast enough so that the water doesn't spill out when the pail is upside down. If Mr. Koper arm is 0.60m long, what is the minimum speed with which he can swing the pail so that the water doesn't spill out at the top of the path?
5. Blackie, a cat whose mass is 5.45 kg, is napping on top of the refrigerator when he rolls over and falls. Blackie has a kinetic energy of 85.5 J just before he lands on his feet on the floor. How tall is the refrigerator?

6. Tubby and his twin brother Chubby have a combined mass of 200.0 kg and are zooming along in a 100.0 kg amusement park bumper car at 10.0 m/s. They bump Ashley's car, which is sitting still. Ashley has a mass of 25.0 kg. After the elastic collision ("bouncy"), the twins continue ahead with a speed of 4.12 m/s. How fast is Ashley's car bumped across the floor?
7. Adam, who's mass is 65 kg, and Andrea, who's mass is 45 kg, sit 2.0 m apart in their physics classroom. a) What is the force of gravitational attraction between Adam and Andrea? b) Does the force of gravitational attraction between them cause them to drift toward each other? Explain.
8. Ivory soap will float when placed in water so that most of the soap is suspended below the surface, and only a small fraction sticks up above the water line. A bar of soap has dimensions of 9.00 cm x 6.00 cm x 3.00 cm and a density of 994 kg/m<sup>3</sup>. What is the buoyant force acting on the soap? (*See Great Buoyancy Lab*)
9. Superman leaves Lois in Metropolis to rescue a malfunctioning space probe sent up from earth. Flying at a speed of 0.70c, Superman reaches the probe in 20.0 hours according to his wristwatch. How long would the trip take according to Lois' clock on earth?
10. What was the temperature at the bottom of Lake Michigan, January 17, 1905? Explain your answer.
11. Meghan, who was absolutely thrilled by the coffee filter lab, decided to investigate the effect of mass on the terminal velocity of coffee filters. She obtains the following data:

Mass of the Filter (g)	Terminal Velocity (cm/s)
1	131
2	188
3	229
4	266
5	292
6	32

She now wants you to assist in analyzing the data and asks

- (a) What does the graph look like? (i.e. sketch it)
- (b) What is the relationship between terminal velocity and mass?
- (c) What is the equation of the graph?
- (d) What are the units of the slope?
12. Joe laughs from his plane as some poor circus performer fires a cannon. At which location does the cannonball have the greatest vertical velocity?

13. Superman is said to be able to “leap tall buildings in a single bound.” How high a building could Superman jump over if he were to leave the ground with a speed of 60.0 m/s at an angle of  $75.0^\circ$  to the horizontal?
14. Amanda is testing her baby’s bath water and finds that it is too cold, so she adds some hot water from a kettle on the stove. If Amanda adds 2.00 kg of water at  $80.0^\circ\text{C}$  to 20.0 kg of bath water at  $27.0^\circ\text{C}$ , what is the final temperature of the bath water?
15. The diagram below shows .....

Sketch a graph for displacement vs. time, velocity vs. time, and acceleration vs. time for the penny.

### **PART TWO – MULTIPLE CHOICE**

1. A car rounds a horizontal curve of constant radius at a constant speed. Which diagram Best represents the directions of both the car’s velocity,  $v$ , and acceleration,  $a$ ?
- (a) (b) (c) (d)
2. While riding a chairlift, a 55-kg skier is raised a vertical distance of 370 meters. What is the total change in the skier’s gravitational potential energy?
- (a)  $5.4 \times 10^1 \text{ J}$  (b)  $5.4 \times 10^2 \text{ J}$   
 (c)  $2.0 \times 10^4 \text{ J}$  (d)  $2.0 \times 10^5 \text{ J}$
3. A 60 kg physics student would weigh 1560 N on the surface of planet X. What is the magnitude of the acceleration due to gravity on the surface of planet X?
- (a)  $0.038 \text{ m/s}^2$  (b)  $6.1 \text{ m/s}^2$   
 (c)  $9.8 \text{ m/s}^2$  (d)  $26 \text{ m/s}^2$
4. A pendulum is swinging upward and is halfway toward its highest position, shown below, when the string breaks. Which of the paths shown best represents the path the ball would take after the string breaks?
- (a) A (b) B (c) C (d) D (e) E
5. A 1,200-kg car traveling at 10 m/s hits a tree and is brought to rest in 0.10 s. What is The magnitude of the average force acting on the car to bring it to rest?
- (a)  $1.2 \times 10^2 \text{ N}$  (b)  $1.2 \times 10^3 \text{ N}$   
 (c)  $1.2 \times 10^4 \text{ N}$  (d)  $1.2 \times 10^5 \text{ N}$

6. Two spheres, A and B, are simultaneously projected horizontally from the top of a tower. Sphere A has a horizontal speed of 40 m/s and sphere B has a horizontal speed of 20 m/s. Which statement best describes the time required for the spheres to reach the ground and the horizontal distance they travel? [Neglect friction and assume the ground is level.]

- (a) Both spheres hit the ground at the same time and at the same distance from the base of the tower.
- (b) Both spheres hit the ground at the same time, but sphere A lands twice as far as sphere B from the base of the tower.
- (c) Both spheres hit the ground at the same time, but sphere B lands twice as far as sphere A from the base of the tower.
- (d) Sphere A hits the ground before sphere B, and sphere A lands twice as far as sphere B from the base of the tower.

7. A 60-kg skydiver is falling at a constant speed near the surface of the Earth. The magnitude of the force of air friction acting on the skydiver is approximately

- (a) 0 N
- (b) 6 N
- (c) 60 N
- (d) 600 N

8. A child is riding on a merry-go-round. As the speed of the merry-go-round is doubled, the magnitude of the centripetal force acting on the child

- (a) remains the same
- (b) is doubled
- (c) is halved
- (d) is quadrupled

9. As a ball falls freely (without friction) toward the ground, its total mechanical energy

- (a) decreases
- (b) increases
- (c) remains the same

10. In the diagram below, a 20 N force due north and a 20 N force due east act concurrently on an object, as shown in the diagram below.

The additional force necessary to bring the object into a state of equilibrium is

- (a) 20 N, northeast
- (b) 20 N, southwest
- (c) 28 N, northwest
- (d) 28 N, southwest

11. Which of the following occurs *after the mass hits the floor*?

- (a) no motion
- (b) with constant nonzero velocity

- (c) constant acceleration less than 10 m/s/s but greater than 0
- (d) constant acceleration equal to 10m/s/s

12. A clutzy physics teacher drops a 3.0 kg stone on his foot. It has a speed of 10m/s just before it hits the foot, and it slows down and stops in 0.02 seconds. Which of the following is closest to the magnitude of the force exerted *by the foot on the stone*?

- (a) 30 N
- (b) 150 N
- (c) 1500 N
- (d) 3800 N

13.  $6.022 \times 10^{23} + 1.680 \times 10^{21} =$

- (a)  $7.702 \times 10^{23}$
- (b)  $7.702 \times 10^{21}$
- (c)  $6.039 \times 10^{21}$
- (d)  $6.039 \times 10^{23}$

14. The area under a velocity-time graph gives:

- (a) work
- (b) velocity
- (c) area
- (d) displacement

15. Mark decided to stand on a bathroom scale in an elevator in The Empire State Building. He normally weighs 800 N and for one second the scale read 700 N. During that time Mark's motion can be described as:

- (a) Constant acceleration, up
- (b) Constant speed, down
- (c) Constant acceleration, down
- (d) Constant speed, up

16. Which graph shows the motion of Mr. Koper's daughter as she rides in her wagon at constant velocity?

- (a)
- (b)
- (c)
- (d)

17. Mr. Musser shot a howitzer (cannon) last weekend. Shortly after the smoke cleared the bullet (all 33 pounds of it) was about 1/3 of the way along its trajectory. Which of the following best represents the directions of the horizontal speed, vertical speed, force and acceleration of the shell?

- (a)
- (b)
- (c)
- (d)

18. To a person who is inside a spaceship moving close to the speed of light, a meter stick held horizontally inside the ship looks

- (a) longer.
- (b) shorter.
- (c) wider in the direction of motion.
- (d) just the same as always.

19. Einstein reasoned that

- (a) all motion is relative.
- (b) a spaceship can only measure its speed relative to other objects.
- (c) there is no unique spot relative to which all motion can be measured.
- (d) all of the above.

20. Heather rides KingdaKa, the tallest coaster in the U.S., as her senior class takes a trip to Six Flags in New Jersey. If the coaster plunges 456 feet from rest at the top of the biggest hill, what is the speed that Heather reaches at the bottom of the hill?

- (a) 170 ft/s
- (b) 216 ft/s
- (c) 68 ft/s
- (d) 53 ft/s.