

## **Students – Ask Them to Eat Their Steaks!**

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Julian received his Ph.D. from Virginia Tech in Engineering Mechanics in 2007. He spent a semester teaching at community college in the area and then spent two years at University of Massachusetts continuing his research in finite element modeling and biomechanics and continuing to teach. He has been at the University of Southern Indiana since 2010.

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### **Abstract**

Some faculty in large-scale engineering classes have turned to using only online homework-based systems such as Pearson's Mastering, Wiley Plus, and/or McGraw Hill's Connect to assess student learning. These systems provide content, grading and assessment of student work, and feedback to students while solving problems. Previous research has shown that students' value both online and handwritten homework. Even students who disliked online homework found it to be at least somewhat helpful. The current project investigates if performance on higher stake (e.g., more heavily weighted in overall grade) activities is better than on lower stake activities in a Dynamics class and a General Physics I class. In our research online homework, handwritten homework, and exams are classified as low-, medium-, and high-stake activities, respectively.

When evaluating the data, the percentage grade for each of the high-, medium- and low-stake activities was recorded for each student and compared against the remaining data sets. The analysis was conducted for each class individually and both classes combined. Results from all three analyses indicate there is no significant difference between the averages of the different levels of stakes. However, in evaluating the data, it appears that, a good correlation may develop between the high-stake vs medium-stake events and medium-stake versus low-stake events late in both the Dynamics and Physics courses.

### **Introduction**

Online homework systems, and therefore the study of their effectiveness, have proliferated STEM [1]–[9] and business disciplines [10]–[13]. Penner et al. provide a summary of the findings of 7 studies and the “overall assessment” of the corresponding studies, since 2001 [3]. They show that there are mixed results from their survey of studies. However, there is generally support for using online homework in classes along with traditional (hand written) homework.

Only a few studies have investigated if the mixture of online and hand written homework affects student performance on graded events [14]–[16]. One study found improvement in overall grades of a Chemistry course, but suggest that scores may have been improved further if students had practiced writing organic compounds by hand [14]. Another study examined three modes of homework (Online Only, Hand Written only and Hybrid) between 3 different engineering classes and showed that students performed best when a hybrid style (both online and hand written) of homework was assigned [15].

This correlation between student performance on online homework assignments and exams has been investigated in engineering mechanics courses for several years now [2], [4], [9], [15], [17], [18]. In fact, a longitudinal study shows online homework leads to better student performance in a future mechanics of materials course [6] while others suggest a combination of the two is best [14], [15]. These works suggest that handwritten homework may provide a “muscle-memory” that will benefit students on future exams. However, evidence still exists that

students do like online homework for its immediate evaluation of answer – without input on solution method [19].

In the present study, we investigate if there is a way to combine online– and handwritten–homework based on the percentage of their value toward a student’s final grade (their stake value) to affect student performance. We predict (H1) a positive correlation between all homework types and exam scores. We also predict (H2) a higher correlation when comparing high–stake scores and medium–stake scores versus the correlation between high–stake scores and low–stake scores within the same exam period. This suggests that students will best be able to successfully apply their knowledge from handwritten homework to their exams. Finally, we predict (H3) lowest correlations will occur between medium–stake scores and low–stake scores. This suggests that students may be using online homework as a place to make mistakes before having to turn in handwritten homework.

## Methods

One Physics and one Dynamics class were recruited to participate in this study. They are both typical lecture-based course in which homework was assigned weekly. The courses were selected because they both use Pearson’s online homework software in the course. They are taught by different instructors. Homework assignments consisted of one or two textbook homework problems that required a handwritten solution and two to three online problems that were graded by the online homework system.

In the Dynamics class, two handwritten problems and 4 online homework problems were assigned per week. Online homework (low–stake) settings allowed for multiple entries with only minor deductions for incorrect answers. These problems were graded out of 3 points. The handwritten problem (medium–stake) was graded for correctness, presentation, and formatting. Generally, key components required for a complete homework problem include neatly drawn free body diagrams, aligned general equations, problem specific equations and boxed solutions. These problems were graded out of 10, with percentages assigned to each key component. In the Dynamics class, homework accounted for 28% of the overall grade. Exams counted as the “high–stake” event. Exams consisted of 3-5 problems, formatted similar to textbook problems, and were graded similarly to handwritten homework assignments.

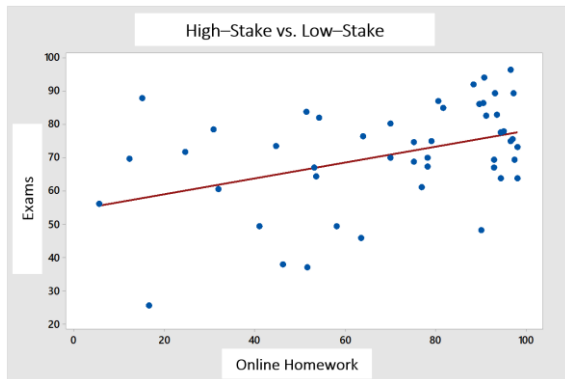
In the Physics class approximately 10 online homework problems, one pre-lecture video and an additional 3-4 handwritten problems were assigned per chapter on Mastering Physics from Knight [20]. Online homework problems consisted of qualitative questions worth 2 points and quantitative questions worth 4-8 points depending on length. A typical assignment was about 60 total points. The pre-lecture videos were worth 10 points each. The final score in this category was calculated as a percentage of total points and worth 10% of the overall grade and constituted the low–stake assessment.

Of the 3-4 handwritten problems assigned, only one handwritten problem was graded per assignment and the students did not know which problem that would be ahead time. The problems were a combination of textbook problems from Knight [20], Giancoli [21], and problems written by the instructor. Each problem was graded out of 10 points on clarity of steps shown, correctness, and answering the question with a complete sentence. The expectations for these problems were discussed in lecture and set the standard for an exam. The average score of

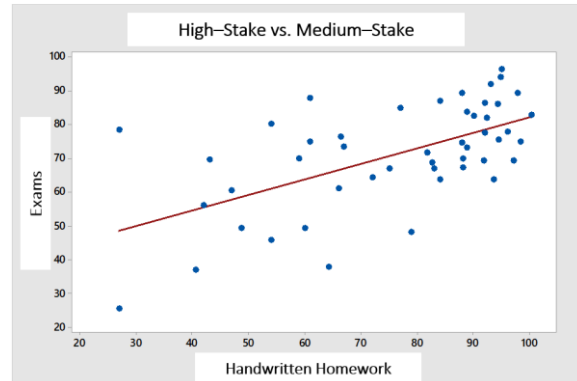
the handwritten problems was worth a total of 15% of the overall course grade, making this the medium-stake assessment. The high-stake assessments were the 4 in-class exams (not including the final). The top three scores counted for 30% of the overall grade and the lowest exam grade was dropped.

## Results

A regression of the averages of the combined Physics and Dynamics low- and medium-stake scores (online and handwritten homework respectively) against high-stake scores show handwritten homework is a better predictor of exam scores (higher slope on linear regression). This is probably the result that we, as educators would all expect – higher correlation between handwritten homework and exam scores.



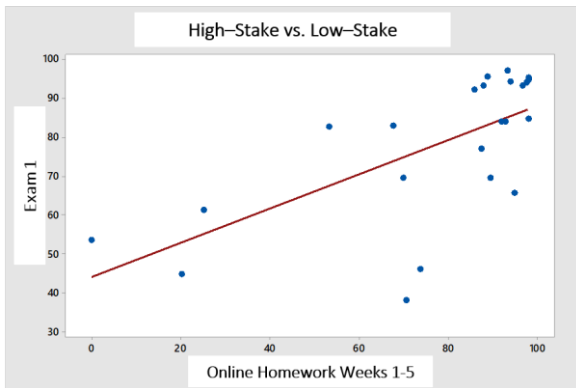
Exam 1 vs. Online HW Score



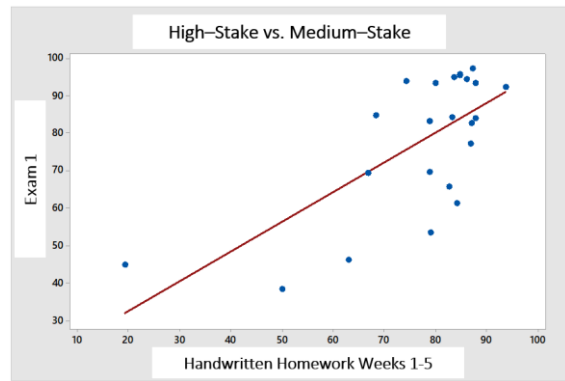
Exam 1 vs. Handwritten HW Score

**Figure 1:** Low and Medium Stake vs. High Stake scores for both Dynamics and Physics Classes combined.

When investigating the correlations within each class, we see very similar results; better or equivalent correlation between online- and handwritten-homework and the corresponding exam (See Figs. 2 and 3).

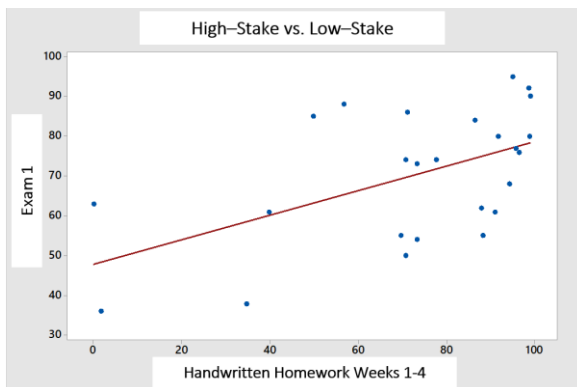


Exam 1 vs. Online HW score

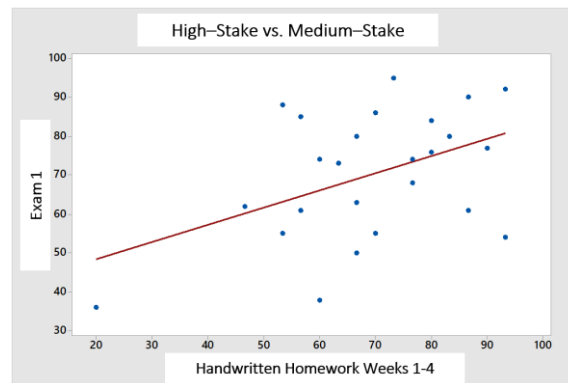


Exam 1 vs. Handwritten HW score

**Figure 2:** Dynamics Exam 1 scores and corresponding low and medium stake scores



Exam 1 vs. Online HW score



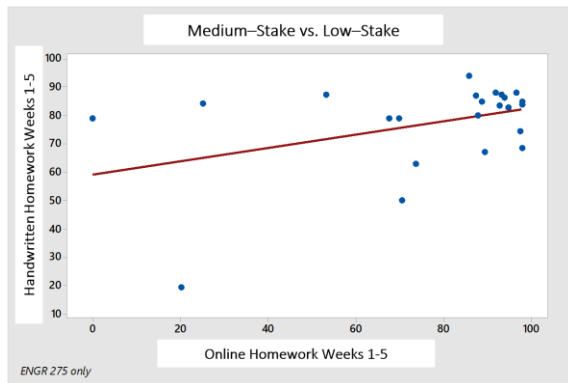
Exam 1 vs. Handwritten HW score

**Figure 3:** Physics Exam 1 scores and corresponding low and medium stake scores

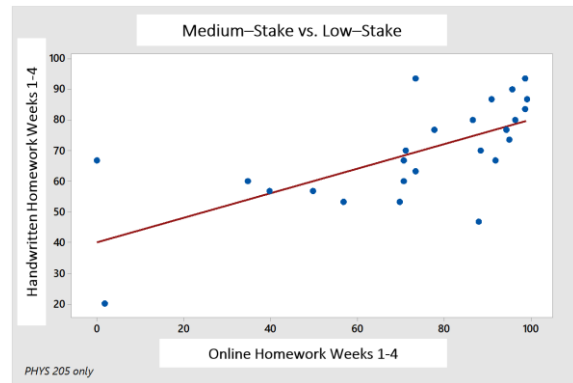
The correlations for high-stake events compared to medium-stake and low-stake events are summarized in Table 1, below. In addition, comparisons between medium-stake and low-stake events are included. These represent scores for handwritten and online homework assignments leading up to each exam period identified. Examples of these plots are shown in Figure 4.

**Table 1:** R-squared values and correlation coefficients in parentheses for high–stake vs. low–stake scores, high–stake vs. medium–stake scores and medium–stake vs. low–stake scores for each class.

Exam	Dynamics			Physics		
	High- vs. Low- Stake	High- vs. Medium- Stake	Medium- vs. Low- Stake	High- vs. Low- Stake	High- vs. Medium- Stake	Medium- vs. Low- Stake
1	43.0% (r = 0.66)	47.8% (r = 0.69)	16.3% (r=0.40)	28.5% (r = 0.53)	20.5% (r = 0.45)	45.1% (r=0.67)
2	3.4% (r = 0.18)	34.7% (r = 0.59)	18.6% (r=0.43)	4.1% (r = 0.20)	3.5% (r = 0.19)	36.6% (r=0.61)
3	2.2% (r = 0.15)	43.0% (r = 0.66)	47.4% (r=0.69)	22.8 % (r = 0.48)	27.9% (r = 0.53)	34.8% (r=0.59)
4	N/A	N/A	N/A	32.3 % (r = 0.57)	39.4% (r = 0.63)	77.1% (r=0.88)



Dynamics



Physics

**Figure 4:** Handwritten HW vs. Online HW scores for the period up to the first exam for Dynamics and Physics

These data, and the plots included in the appendix, show that online homework does positively influence all forms of assessment. Most significantly, as time progresses into the later exams (late in the semester), both classes, Dynamics and Physics, see strong correlations between handwritten homework and online homework, and then between exams and handwritten homework.

In addition, there is a drop in high–stake correlations between exams 1 and 2, in both classes. This could probably be due to the timing of exams with other courses and prioritizing of other courses relative to the ones included here. This has been confirmed with physics students; they did have a Calculus exam earlier on the same morning.

## Discussion

After looking at the results from both classes, it is difficult to say if dividing the grading of the assignments into low-, medium- and high-stake events encouraged students to take the low-stake homework as opportunities to make mistakes and learn from them, and then use the medium-stake events as opportunities to get feedback from professors. We certainly have seen here the same results as what we have seen before; handwritten work is a better correlation to exam performance than online homework.

Certainly, in the physics class, it seems as if students treated the online homework almost as equally as the handwritten homework. In fact, when comparing exam or high-stake scores to homework (medium- or low-stake) scores, the difference between the correlations is small ( $|\Delta r| < 0.08$ ). This is probably an indication that online and handwritten homework both contributed equally to a student's exam performance and potentially learning. However, it may also indicate that the online homework was not used as the low-stake learning tool as we intended.

In Dynamics there is a large difference in correlations using this same comparison, in the periods leading up to exam 2 ( $|\Delta r| < 0.41$ ), and exam 3 ( $|\Delta r| < 0.51$ ). This may indicate that students put more emphasis on the handwritten homework over the online homework. An interesting result here is that the online homework was very poorly correlated with exam scores in the Dynamics class – lowest correlations among all correlations in all classes. It is probably too easy to think here that students did not learn anything from the online software. This could be an indication that students did in fact use the online homework as a pedagogical tool as we intended. Online homework was there for them to build their foundational framework a low-stake learning tool, on which they could then build further for their handwritten homework as a medium-stake learning tool.

Two things to consider with our results are that there could be an influence of the academic level of the students in the classroom. The physics class is usually taught to freshman or first-semester-sophomores, whereas the dynamics class is usually taught to second-semester-sophomores. Another consideration is the familiarity with the software. Coming into Dynamics, students are familiar with Pearson's software, and may not have as many problems in Dynamics as they may have when they were first exposed to it in Physics.

The most interesting aspect of the results is what happens at the end of the course; there are good correlations between medium-stake vs. low-stake scores and between high-stake vs. medium-stake scores. This may imply that there could be a building component of online homework helping students with their handwritten homework, which is also correlated with improving their exam performance. These are very interesting results and could be an indication of how to best use online homework systems in conjunction with other assessment methods. Use online homework to improve a student's ability to solve problems and present them as handwritten work. Then use the handwritten assignments to improve as student's ability to perform on their exams.

Finally, we predicted lowest correlations to occur between medium-stake scores and low-stake scores suggesting that students would use online homework as the low-stake assessment; a place to make mistakes before having to turn in the medium – stake assessment (hand-written homework). This was incorrect. The lowest correlations came in most often in the

high-stake versus low-stake comparisons indicating the online homework is not a good predictor of how students will perform on high-stakes assessments (exams).

## Conclusions

The problem that we set out to investigate is if there was a method of using the tools that we give students to increase their learning and retention in a Dynamics and Physics class. We cannot say anything definitive about these tools, yet. However, we see evidence that there is steady, if not increasing correlation between online and handwritten homework when treated as low-stake and medium-stake assignments. We suspect that this may be an indication of a building of knowledge or problem solving skills throughout the course.

There are generally positive correlations between all homework types and exam scores. In addition, higher correlations between high-stake scores and medium-stake scores versus between high-stake scores and low-stake scores within exam periods was observed consistently in the Dynamics class and in the last two exam periods of Physics. However, the differences between these correlations among all the exam periods in Physics were very small ( $|\Delta r| < 0.08$ ). So, the evidence here is not as dramatic as observed in Dynamics.

The message here is not to determine whether online homework is *better* than handwritten homework; they are simply two methods of learning content and how to solve problems. We do observe generally positive trends in correlations between all assessments. These data seem to indicate that online homework can be used as a building block for handwritten homework, which is the best predictor for how students will perform on exams. We will continue to investigate to determine the best mixture of these two learning tools to enhance student learning.

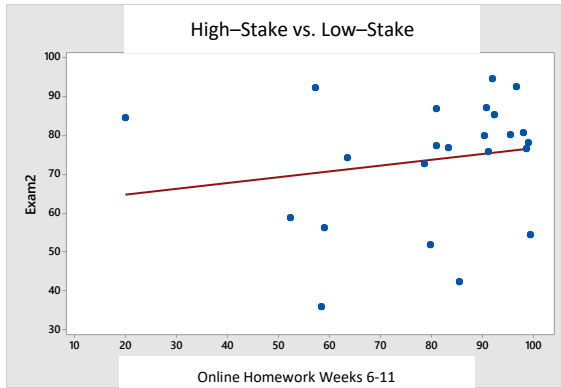


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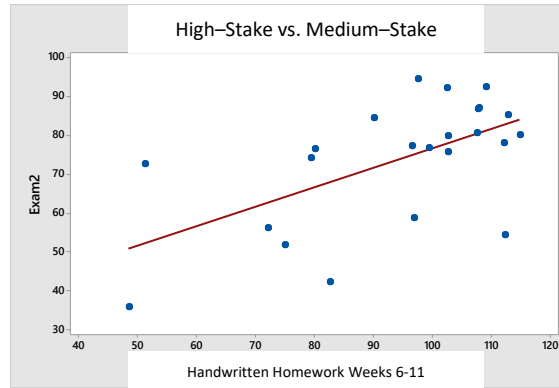
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## Appendix A: Dynamics Stake Plots

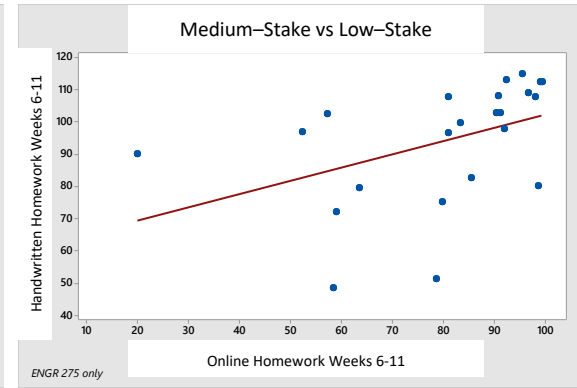
Extra plots of High-, Medium- and Low-stakes scores.



Exam 2 vs. Online HW score

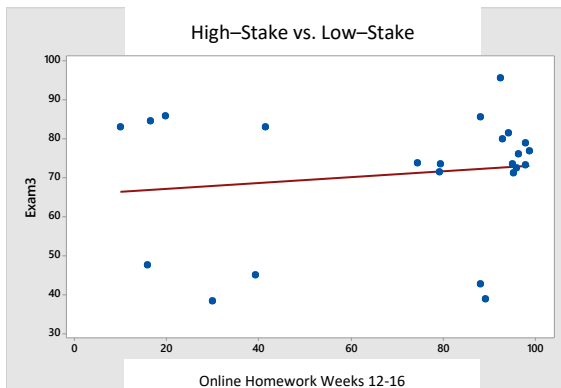


Exam 2 vs. Handwritten HW score

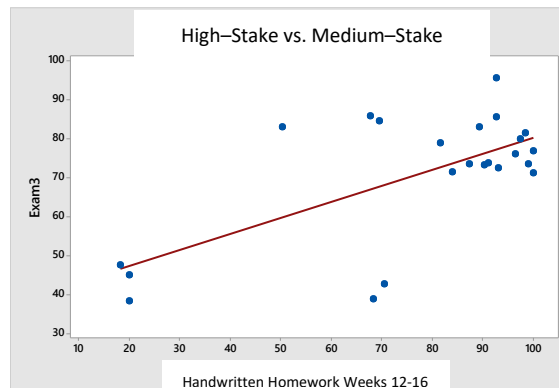


Handwritten HW score vs. Online HW score correlating to Exam 2

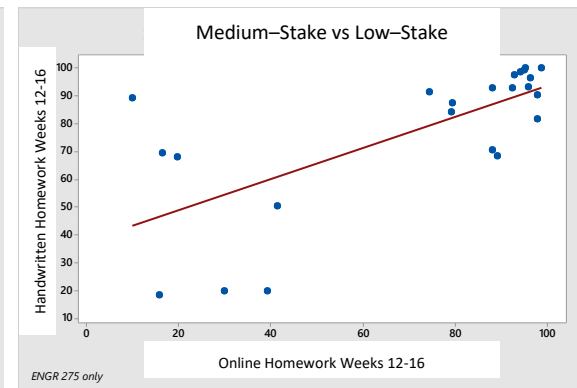
**Figure A1:** Dynamics Exam 2 scores and corresponding high-, medium- and low-stake comparisons



Exam 3 vs. Online HW score



Exam 3 vs. Handwritten HW score

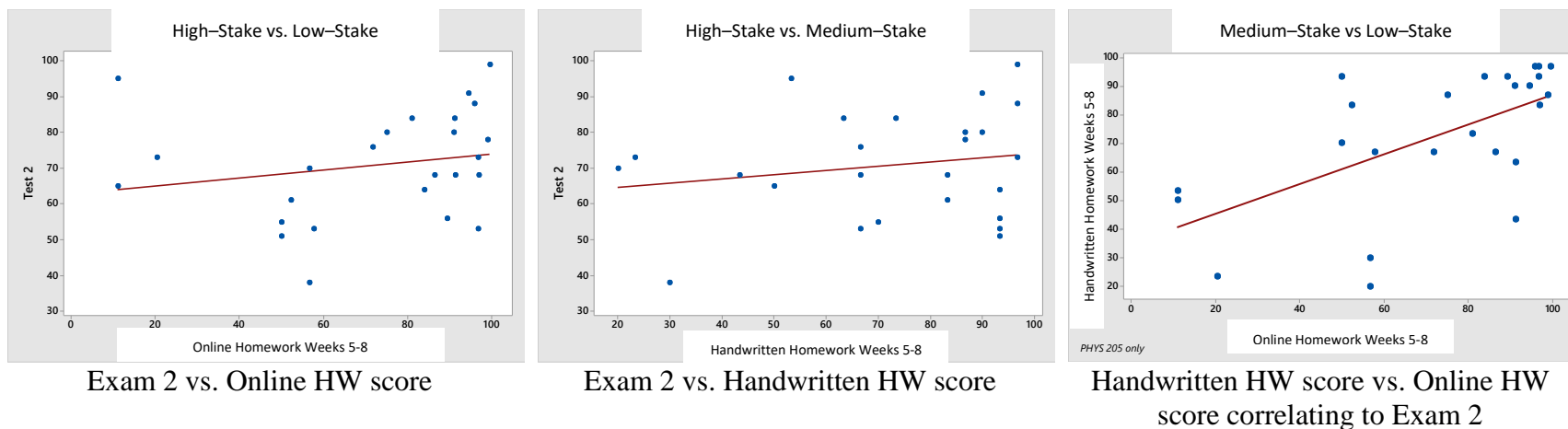


Handwritten HW score vs. Online HW score correlating to Exam 3

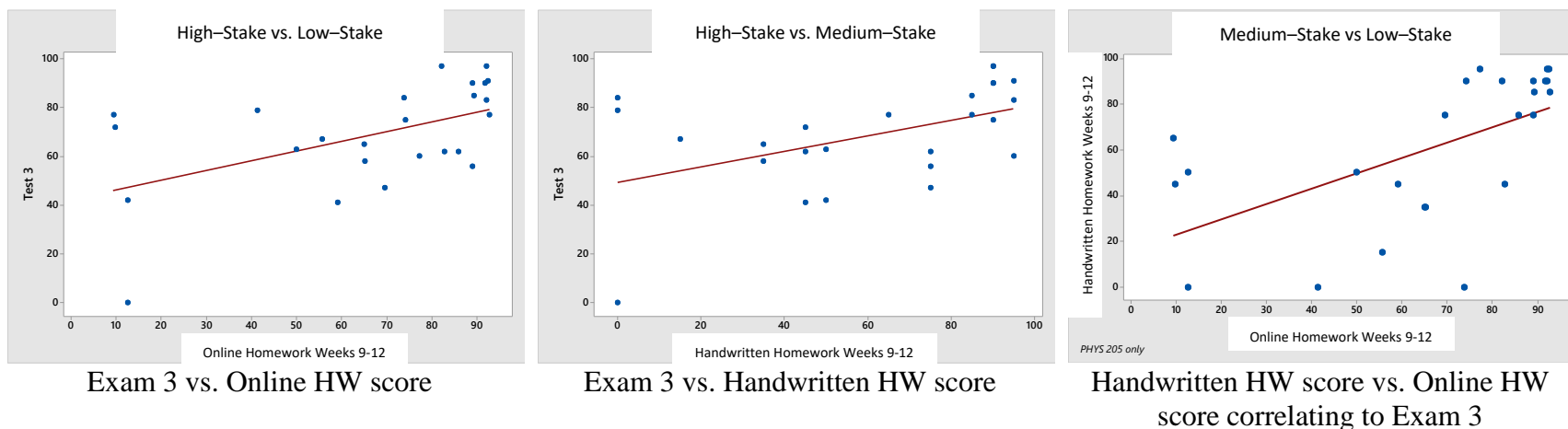
**Figure A2:** Dynamics Exam 3 scores and corresponding high-, medium- and low-stake comparisons

## Appendix B: Physics Stake Plots

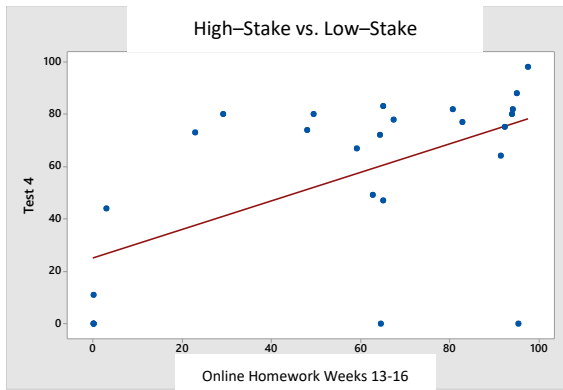
Extra plots of High-, Medium- and Low-stakes scores.



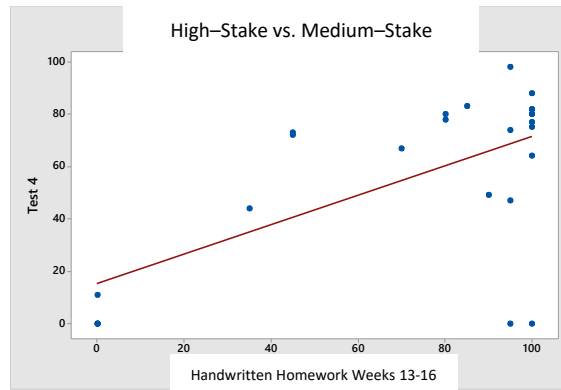
**Figure B1:** Physics Exam 2 scores and corresponding high-, medium- and low-stake comparisons



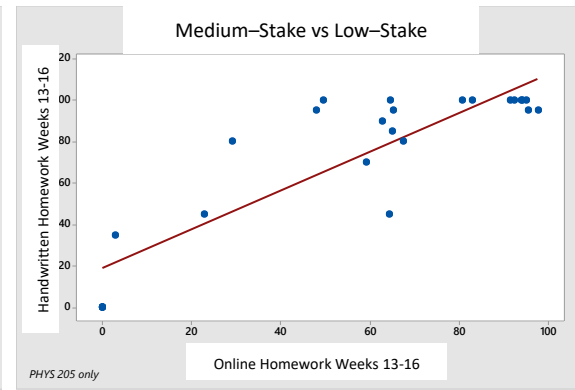
**Figure B2:** Physics Exam 3 scores and corresponding high-, medium- and low-stake comparisons



Exam 4 vs. Online HW score



Exam 4 vs. Handwritten HW score



Handwritten HW score vs. Online HW score correlating to Exam 4

**Figure B3:** Physics Exam 4 scores and corresponding high-, medium- and low-stake comparisons