

# Effectively using Online Homework

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**Abstract** - Recent enhancements to a customized online homework system used in a large, first-year physics for engineers class are presented. Some of the changes that are discussed include the following. Examples were added, initially just being references to textbook examples, and then links to instructor-generated examples, and finally short videos of solutions to the examples. There has always been a direct link to a discussion board, but now discussion board posts from previous semesters have also been made available to students. A units utility has been added whereby students have to enter units, rather than the units be specified. An automated intermediate value check has been added, where students can check some intermediate values with no grade penalty. Common mistakes and unreasonable answers are identified, with a warning given to the student. There are several common mistakes that are automatically checked for each problem, such as being off by a multiple of 10. Each of these interventions has proven to be helpful, but there have also been unintended consequences. These are discussed in the paper.

*Index Terms* – Online homework, physics, first year engineering, discussion board.

## INTRODUCTION

The freshman engineering program at the University of Tennessee consists of two 4 hour courses, Physics for Engineers I and II. The content of these courses is an introduction to engineering physics (approximately the first 20-25 chapters of an introductory engineering physics textbook), and an introduction to elements of successful engineering practice (teamwork, engineering design, and communication). The courses use a customized web-based homework system [1]. This system provides individualized homework [2,3]; each student has the same problem but different parameters. Some of the features of the online homework are that each homework has a direct link to a discussion board, students can save notes for the staff to see when assisting the student through the discussion board, and students can upload images through scans, picture texts, or a sketching utility [4]. All homeworks have multiple parts, and answers for each part can be submitted separately. Each part has a 2% penalty for each incorrect answer submitted. A bonus system is used [5]-[6] whereby students can earn a 10% bonus for all homework completed more than 24 hours in advance of the due date. A late penalty decreases linearly from 0% penalty to 25% penalty over the first 48 hours after

the homework was due. The penalty remains at 25% through the module, and then drops to 50% after the module.

The homework system has been continually updated. The reasons for some of the recent changes, the pros and cons of each enhancement, and student feedback on the changes are given.

## EXAMPLE PROBLEMS

Several years ago we added hints to certain problems that were example problems in the text book that related to the homework. Since we have gone to the textbook being recommended instead of required, students complain about being referred to the textbook, since they did not buy it. We have added in worked out related examples for some of the homework problems. These have been reasonably positively received, with 18% saying the examples were very good, 34% good, 29% average, 12% marginal, and 5% poor. There has been a small amount of feedback saying that the examples were not relevant, or that the examples were not similar to the homework. For the most part, we believe that not to be true; we are not going to provide an example that is identical to the homework problem although that is what some students want, or have been used to in high school.

We have started posting video solutions to old exam problems, and those have been very well received. Students have said those have been very helpful, and have asked for more videos. We are exploring several options, including having videos of the example problems, or using a keyword index, so students could see all of the problems and exam solution videos related to a certain topic.

## DISCUSSION BOARD

For many years the online homework system has had a direct link to a discussion board. Typically the discussion is monitored by a graduate teaching assistant for a few hours several evenings a week, with periodic monitoring by faculty at other times. We have received positive feedback on the discussion board, with students appreciating that the discussion board was integrated with the homework and the direct link from the homework that would filter the discussion board to only posts related to that homework. We found we were answering a lot of the same questions semester after semester. We also received comments such as “I liked seeing other people's questions that are similar to mine and seeing your advice.” We decided to link to discussion board posts on the same question from previous

semesters. The idea was that students would get be able to get more immediate feedback.

Table 1 compares statistics from Fall 2012, when there was not a link to previous semesters, to Fall 2013, when there was a link to previous semesters. The overall number of questions asked dropped, but the usage and effectiveness of the discussion board increased. We received comments such as “Looking at past sections questions was really helpful, because often times someone would have already asked a question similar to mine or made a mistake I also made;” “Definitely keep the questions from previous semesters. 9 times out of 10, I was able to figure out my questions by looking at the previous semester questions.”

There are two drawbacks to linking to previous semesters. If the homework problem was changed, then the previous semesters responses did not make any sense. Some students also admitted to the discussion board being a crutch; there was sufficient information for them to work the homework problem but they did not fully understand the problem. This is true of any help provided, but linking to previous semesters provided even more information that could be used as a crutch. Overall, we feel the benefits outweigh the issues, and we will continue to link to previous semesters.

TABLE 1  
DISCUSSION BOARD FEEDBACK

Parameter	Fall 2012	Fall 2013
Average questions per student	1.45	1.01
Effectiveness of discussion board (5 point Likert scale)	4.15	4.19
Use of discussion board		
• Never	5%	5%
• 1-4 times	12%	9%
• 5-10 times	20%	13%
• 11-20 times	22%	18%
• > 20 times	41%	56%

### UNITS

The originally developed online homework system specified the required units for every answer. Although this was useful for a few beginning homework problems to require students to learn units conversion, there were several problems with this. A few students told us that they would work towards the units given for the answer without understanding the problem. As the course progressed, the unit conversions could become a burden. We felt students should both have to figure out the units of the answer, and be free to work in whatever units they wanted, including our favorite length unit of beard-second. Therefore, recently the system was updated to where students had to input the units with their answers. The units utility was the free GNU units utility, [www.gnu.org/software/units/](http://www.gnu.org/software/units/), integrated into our custom system. We have retained a few initial problems in which the units are specified to teach units conversion. We

often use fictitious units for these problems so students have to work through the units conversions steps, and not just use the units conversions in Google.

Student feedback to requiring units is given in Figure 1 over the two semester class sequence. These were essentially the same students. The perception of helpfulness of the units increased in the second semester, possibly due to familiarity. Although survey comments showed a little frustration with the units, overall it was positive, perhaps best summed up in the comment “Putting in units sucks, but I feel like it helps students figure out what they are actually talking about.”

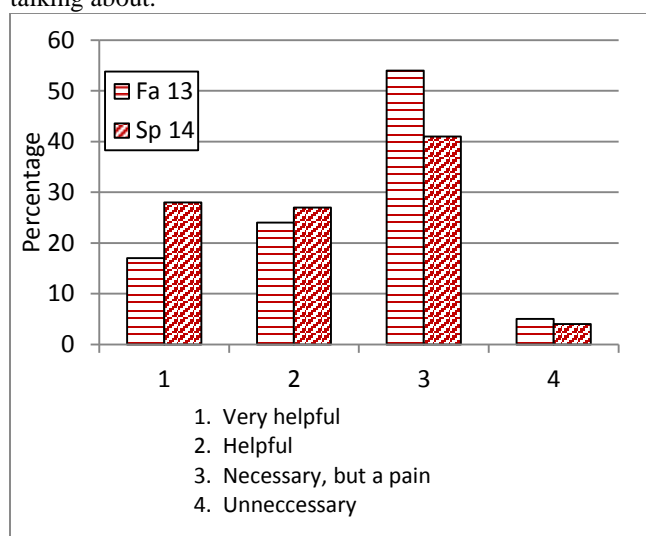


FIGURE 1  
STUDENT THOUGHTS ON REQUIRING UNITS

### INTERMEDIATE VALUE CHECK

When we were asked questions about a homework problem, one of the first things we usually did was to check intermediate values of the problem. This has been automated, where students can check intermediate values with no grade penalty. An example is a homework problem to find reactions of a beam with several applied loads. An intermediate value check would be the moment of one of the forces about a certain point. The challenge is to develop appropriate intermediate value checks that are useful but do not give away the solution process of the problem.

Not surprisingly, the students very much liked the intermediate value checks, with 92% of the students rating the intermediate value check as either very useful or useful. As part of the intermediate value check pop-up box, we also had an optional suggestion box, where students could enter comments and suggestions on hints and intermediate value checks. We received very little useful feedback from the suggestion box, although occasionally there was a good idea. Generally the suggestions essentially amounted to having an intermediate value check for the answer so students could check their answer without losing any points.

### COMMON MISTAKES

The online homework system is capable of checking for common mistakes and unreasonable answers. If a student has the basic solution technique correct, but just made a minor error, we do not want them questioning their solution technique, or spending a lot of additional time on the problem. It also did not seem to make sense for a student to post a question on the discussion board and have to wait for someone to answer to just tell them to check the sign of their answer. For efficiency, several global common mistake checks have been implemented, or checks against which each submitted answer is checked. These include wrong sign, off by some magnitude of 10, off by a factor of 2, and off by a factor of  $g$  (either 32.2 or 9.81). Specific common mistakes can also be programmed for each problem, such as using  $\sin$  instead of  $\cos$  to find a vector component. Unreasonable checks, such as mass being less than 0, can also be programmed into individual problems.

Anecdotal feedback on this change has been positive. Students appreciate getting immediate feedback and guidance. Determining what might be a common mistake or an unreasonable answer for a specific problem is not always easy. Often we program in a common mistake or unreasonable answer as a result of a question, typically a question asked on the discussion board.

Although we believe the feedback provided by common mistakes is very useful, there are some drawbacks. We have had several students say that they were able to get the problem correct because the common mistake told them they were off by a factor of 2, but they did not know why they were off by that amount. We also have students who get the message that they are off by some magnitude of 10, and just start guessing different multiples of 10 rather than trying to figure out the issue. Finally, some of the global common mistakes may not make sense depending on the problem. For example, the common mistake of being off by 9.81 is for mechanics problems where students have used mass instead of force, or vice versa. However, by coincidence, a student may get the message when working a capacitor problem, which can confuse the student.

We believe common mistakes are helpful. The best system would be to have common mistakes for each problem. That requires a lot of time, so a balance has to be struck between efficiency and the best system.

### RANDOM PROBLEMS

In addition to having random parameters, we have recently added additional problems. Students now will get a random problem (typically one of three problems is selected) and random parameters. We know that there are detailed solutions to our homework problems available since we require students to keep a portfolio of their work in addition to submitting the answer online. The addition of random problems makes it more difficult for a student to obtain a complete set of solutions for all of their homework.

When we initially added in random problems a problem was created with the discussion board, as the discussion for a particular homework problem (e.g. Module 1, homework 4, problem 3) could be related to three different problems. This was fixed by having the discussion board key off of a unique homework question number, and not the actual homework assignment. The other issue we were concerned with is the effect of random problems on study groups. Ideally this would help a study group as they would be working on slightly different problems, and hopefully focusing on the overall concept, and not the particular problem. However, there is a concern that it could also be frustrating to students in a study group if they had different problems. We are still evaluating the best approach.

### CONCLUSIONS

Homework is an essential part of engineering classes. The challenge with large classes is to provide effective homework in an efficient manner. Several different recent enhancements to a custom online homework system are discussed. Overall the benefits have been positive, but there are also areas that could still be improved. All of the efforts are focused on providing timely help to students while they are working on the homework.

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