

ONLINE ASSIGNMENTS IN FIRST YEAR PHYSICS MODULES

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Introduction

Imagine grading the written assignments of about 1500 students every week during the semester. The task would have to be divided among about fifteen graduate students. Now, imagine trying to ensure fairness in the grading, since these assignments form part of the overall assessment. Imagine also how timely feedback and suitable guidance can be provided to students while they are doing the assignments and after they have submitted them. This was the situation the Physics Department faced some years back, when we designed the engineering physics modules for first year engineering students.

Out of sheer necessity, we evaluated a number of online assignment systems for the freshman Physics modules available at that time, and picked WebAssign as being the most suitable for our purposes then (Feng et al, 2004). Online assignments have now become an integral part of all freshman Physics modules. It has become more than a replacement for written assignments, and we have reasons to believe that many students benefit more from it than we had initially hoped.

The successful implementation of the online system for the engineering physics modules encouraged us to explore the possibility of incorporating this into other first year Physics modules. We evaluated another online system, known as MasteringPhysics, and tested it during AY2005/06 in PC1141 "Physics I", one of the four compulsory freshman modules for Physics majors. A careful comparison of both systems was made and since AY2006/07, MasteringPhysics has been adopted in all our freshman Physics modules (with the exception of PC1144 "Physics IV", which started using the system in AY2008/09).

Advantages of the Online Assignment System

Before the implementation of the online assignments, students were required to hand in one written assignment fortnightly. These assignments were then graded by graduate students and discussed during the class tutorial, usually by a different teaching assistant. There were some disadvantages to this method. First, there was a significant time lag between the lecture and the feedback students received for

their work. Second, the quality of the feedback to the students was dependent on the diligence and quality of the grader. When we implemented the online system for assignments, these issues were resolved and we effectively decoupled the assignments from the tutorials. Each component served a different function: the online assignments as regular reinforcements to what the students learnt in every lecture, and the tutorials as a means for students to get together every fortnight to discuss problems which were set according to the theme of the lectures.

The other advantages the online systems, which applied to both WebAssign and MasteringPhysics, had over written assignments include:

1. Man-hours saved in grading the assignments, resulting in cost savings in terms of employing graduate students to teach big classes (above 100 students), despite having to pay the relevant organisation a nominal sum for supplying the system (e.g. \$10 per student per academic year for MasteringPhysics).
2. Consistency in the grading.
3. Instant feedback to the students.
4. Hints which can be entered into the system (either by the system administrator or our staff).
5. Feedback supplied to the lecturer on how individual students performed, as well as the level of difficulty students experienced for each question.
6. Numerical values which can be randomised so that different students will have different answers for the same questions, a scheme which prevents them from simply copying the answers.
7. Students taking a greater interest in the subject, as many of them are attracted to things that are Internet related. This is particularly true of questions with embedded applets that let students vary the input parameters, which is a very good way for them to learn new problem solving ideas and also lets them see the physics come to life.
8. Availability of the e-textbook so that students can easily refer to the relevant sections while working on the problems.

Comparing MasteringPhysics and WebAssign

Our decision to choose MasteringPhysics over WebAssign was based on the following reasons:

1. The Mastering series of online assignments was started by prominent atomic physicist Professor David Pitchard of the Massachusetts Institute of Technology (MIT). As such, it uses concepts and ideas that are very physics-oriented, e.g. in terms of the ways to enter equations, significant figures, its problem solving methods etc.

2. Hints are built into many of the problems. Most of the hints are appropriate and guide the weaker students very well. In WebAssign, we had to enter the hints ourselves.
3. As MasteringPhysics has been used by many Physics departments in the US and around the world, most mistakes had been corrected and so far, after these institutions have used the system for a few years, no other serious mistakes have been discovered. There were ambiguities in some problems but much fewer as compared to WebAssign, particularly when the numerical values are randomised.
4. A lot of statistics are given for each problem, including the level of difficulty for each problem as rated by the thousands of students who have attempted it, the average time students spent on the problem and the average score they obtained. With this information, we can create a balanced assignment with a combination of easy and difficult problems, and with a certain timeframe in mind (e.g. between 40—60 minutes for each weekly assignment).
5. Three types of problems are available—(i) skills building; (ii) self-tutoring and (iii) end-of-chapter problems taken from *University Physics with Modern Physics* (Young & Freedman, 2007) and *Physics for Scientists and Engineers: A Strategic Approach* (Knight, 2003). The most useful questions we found are the self-tutoring types where very good hints are available to guide students who may find themselves stuck at certain points as they work through the problem. MasteringPhysics has many unique problems that are of this form, which would be very valuable to the students.
6. MasteringPhysics also has a better system to determine whether the answers submitted are correct. If the students' answers were off by a small amount, the system would advise them to check the significant figures again rather than grade their submissions as being incorrect. Different variations of entry of the same algebraic answer are accepted. The extensive use of algebraic answers is a big plus, and they are generally very easy to enter. The system also has a very good engine which compares submitted answers with the accepted answers and thus we received very few complaints from students over the issue of having a different but correct expression which was marked as being incorrect.
7. The system also provided a very good view of students' responses. Not only could we see how each student fared and compare their performance in each question to others who had previously attempted these same questions, we could really go down to individual students and see where they may have gone wrong in a question, or how long they took to do each part. This is very useful in alerting us to students who need our attention.

Implementation

The implementation of MasteringPhysics went smoothly, even though it was the first time this system was implemented in this part of the world. Within the first two sessions, most of the uncertainties and administrative problems were resolved, ensuring that the learning of concepts became the key issues students dealt with.

Our choice of questions determines what the students will ultimately learn. Usually, we would choose 4–5 compulsory problems which every student had to attempt. The time given to complete the assignments was standardised to 9 days, with the submission time usually set at two or three o'clock in the morning, based on our understanding of the working hours our students keep. We expected students to spend 40–60 minutes on the compulsory portion of the assignment.

However, we usually add about 7–10 more questions as optional practice problems. There was neither a bonus nor a penalty for attempting these questions or ignoring them. We found that some students attempted almost all the questions while others did not attempt them at all. This is the result we were in fact looking for, as we wanted our students to decide for themselves if they found the problems beneficial. The most challenging problems were usually left as optional but we included one or two difficult ones as compulsory questions so that students would not be complacent and will also learn a couple of new tricks or methods along the way. They were allowed to consult friends and tutors, or to pose questions in the online forums. They were also allowed to use the hints with very little penalties imposed.

Towards the end of the semester, to make full use of the other good questions in the large database that had not been set for the assignments, we added even more sessions, each of which contained about 20 problems. In fact, a number of students requested access to all the questions in the database which some of us acceded to. All these questions were optional and were included as a substitute “tutor” for students who attempted them.

This component constitutes 10% of the final grades in the modules which use this system. Some assignments were not counted towards the final score. The first task given was a standard assignment for students to get used to the system, as it will force them to use the hints and coach them on how the formula should be entered. The second assignment in the first semester is used as a trial for students to be familiar with Physics problems in the system. We usually drop the lowest scored assignment for each student when we compute the final marks. This helps us reduce the number of appeals from students to extend the deadline. In general, this component rewards students who are diligent and those who collaborate with their friends, qualities we encourage students to cultivate. As we treat the online assignments as an additional learning tool rather than a means of differentiating students according to their ability, we do not consider it a problem when most students score close to the maximum for this component, since about 70% of the grades would still be based on the term test and the final examinations.

Some of us feel that the system has been a great help to the students. We also feel that the answers they provided during the final examinations were better compared to those provided by previous batches before this system was used. In NUS, we have not quantitatively ascertained how much credit can be given to MasteringPhysics for this improvement, but it does support the system's claim that MasteringPhysics significantly improves the grades of students using this system, or as reported in MIT (Lee, Palazzo, Warnakulasooriya & Pritchard, 2008).

A Sample Problem

Figure 1 shows a screenshot of a problem from MasteringPhysics, in which the students are presented with a situation that they can understand better by running an applet which shows the sliding of a block and the rolling of a disk down an inclined plane. Students have to answer a conceptual multiple-choice question (MCQ) which asks them to explain why the block is able to reach the end of the inclined plane earlier than the disk. The students have to get pass this part before the second part of the problem and another applet (as seen in Figure 1) becomes visible.

These applets serve to reinforce what actually happened, which helps students formulate the quantitative reasoning needed to answer the second part of the problem. For students who need more guidance, they can also click on "Hints", which will open another window to show a list of hints that they can use. We may set a small penalty when students open these hints. Students can choose the hints they need. Most of the hints utilise the Socratic style of questioning that guides them towards the final solution.

The final answer can be quite complicated, as is often the case in any Physics problem and as seen in the example in Figure 1. These answers can be written in various algebraic forms, and the system is generally very good in ensuring that all correct forms are accepted.

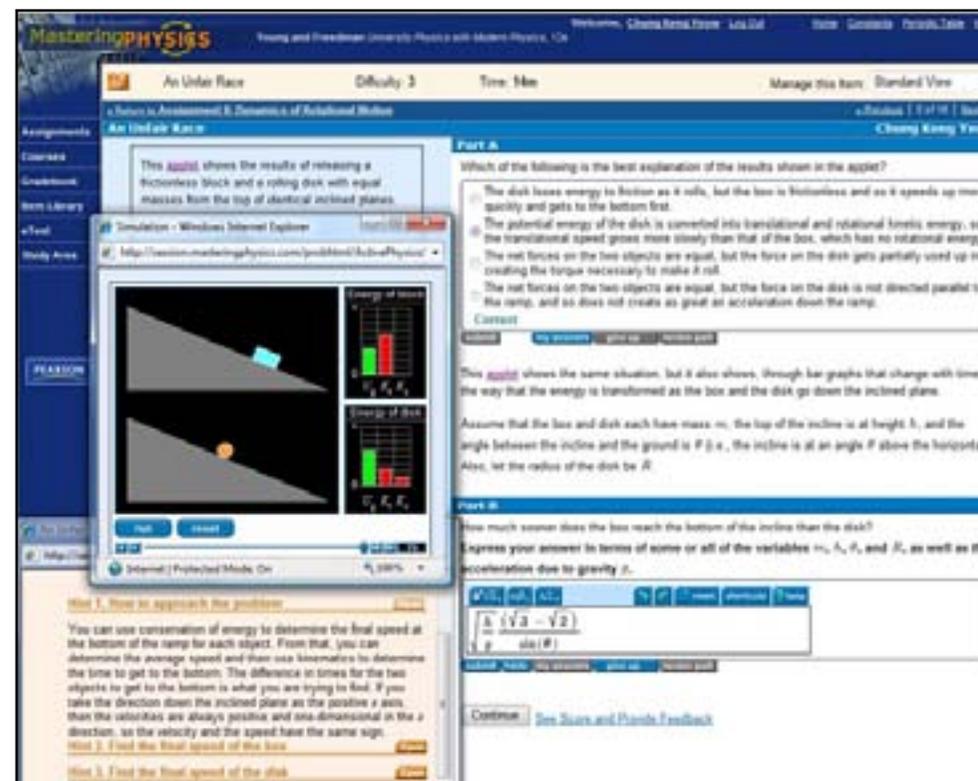


Figure 1. A screenshot of the MasteringPhysics showing three windows—the main question, an applet and hints. Notice that this problem was rated as having a difficulty level of 3 (on a scale of 1–5) and the average time spent on this problem by the thousands of students who had previously attempted this is 14 minutes (as indicated on the top of the screen). Notice also that the student can click on the e-text in the window.

Hints and Feedback

One of the biggest advantages the online assignment has over the written assignment is the "Hints" window, which the students can explore while they are working through the assignments. Most of the hints are built into the system, through the accumulation of the difficulties experienced by other students who had done these problems. The hints can be subtle rather than direct, and often require students to answer some easier questions that are pertinent to the problem they are trying to solve. The lecturer can set the grading criteria such that only a small fraction of the marks is deducted if students open the hints, or a bonus is given if they do not.

Alternatively, as what some of us have done to encourage learning, no bonus or penalty was imposed whether or not students opened the hints, since some of the hints benefit even the better students.

Whenever students give an incorrect answer in their first few attempts, the system would also provide hints on whether it was due to some mistakes with a numerical factor, a lack of precision or some points which they may have obviously neglected. Some students were amazed that the computer seemed to know where their mistakes were. These of course were due to the system's ability to compile the cumulative responses from students and the constant upgrading of the system's database of problems and hints by those who are familiar with the subject.

Another outstanding feature of the system is the amount of information the lecturer can obtain for each completed assignment. Besides furnishing detailed information on any student's work, the system also compares students' overall performance with the other thousands of students who had completed these problems, in terms of the time they took to complete these problems, the difficulty levels and the scores they attained. Furthermore, for every question, the percentages of students making some of the common mistakes are listed. This gives us a good idea of the misconceptions students may have or the difficulties they may encounter in understanding the new concepts.

Some Issues with Using MasteringPhysics

Proofs of formulae and derivation of results are important parts of the learning process in physics. The initial implementation lacked problems of this kind in all the systems we evaluated, for the obvious reason that it was hard for the computer to grade such problems. In recent years, MasteringPhysics has added problems which require students to derive a formula by inputting some critical steps. It has also included conceptual questions where students were expected to give a qualitative explanation. As expected, these implementations were not without problems, as some students felt that marks were not fully awarded for their working. Some of us have avoided setting such problems as compulsory questions, but have included them as optional problems which students may try without any fear of losing any marks.

As with other systems, an electronic version of the textbook is available while students are in the MasteringPhysics system. This allows students who are unsure about how to proceed to refer to the necessary section of the text online. However, the e-book is not very well integrated with the problems as compared to other online teaching and learning systems such as WileyPLUS, where the questions are automatically linked to relevant sections of the book. WileyPLUS was used in the bridging Physics modules for students who did not take A-Level Physics.

To serve as an effective learning tool, MasteringPhysics' values, i.e. in terms of its ability to differentiate the students according to their academic abilities and as a feedback mechanism on how much our students learnt in our lectures, are diminished. By allowing our students to discuss and collaborate, we find that even the weaker students could score very well in this component. With a much lower percentage of wrong answers from our students, we may not be able to get a

very good picture of what they may have not understood from our lessons, or the misconceptions that they may have.

Student Feedback About the System

As our department was the first to adopt the system in this part of the world two years ago, the publisher Pearson interviewed some of our students who used the system in three of their modules. The students were quite frank in their comments and pointed out how they felt about using MasteringPhysics as part of their assessment. Most students gave very positive comments about aspects of the system, such as the feedback it provides after a wrong answer is submitted as well as the hints provided during the attempt. In comparison with normal classroom tutorials, they felt the feedback and hints provided in MasteringPhysics were more specific and helped them understand the parts they had not understood before. According to one student,

- “The feedback helps me pinpoint exactly where my problem is. Then I can go back on my reasoning and see how I can get the right answer in the next try.”

Or as another student commented,

- “I also like the hints—it gives me a step-by-step guide on how to do the questions that I am not very comfortable with. It leads me to the right answers in a systematic way.”

This is similar to another comment in which the student remarked that “[h]ints are really helpful. It helps us conceptualise a lot better—much better than tutorials.”

Some students also used MasteringPhysics as a revision tool after the lectures or before the examination. As one student remarked,

- “Doing the assignment is a very good practice and also for revision. Sometimes we missed certain points in the lectures. Through this possibility we can use it as a safety net so that we can have a thorough view of the whole concept.”

Some students also mentioned the advantages of having the e-book available in the system while they were working on the problems. Other positive aspects mentioned include the presence of animations in the problems and the different types of questions which helped to build up their understanding of the concepts.

While some students appreciated that the assignments forced them to study every week, since it contributes 10% to their final grade, others have also commented that it has also become an additional source of stress in their academic lives. This was coupled with the frustration some felt about how the assignment can be time-consuming, particularly the long loading times for the questions, and the fact that they can only see and work on one problem at a time. One student also commented that, “[s]ometimes we thought that the answer was correct but somehow the system requires us to type something else.”

Some Concluding Remarks

Using technology to enhance our students' learning has been an important development in pedagogy in higher education, and one which many of us have made substantial use of. Intelligent and selective use are key to the successful implementation of any system.

It is important to bear in mind that human interaction is still an integral part of learning. While the online assignment system "automates" the marking of students' answers and provides feedback and hints to students, it is still our responsibility to provide the human factor, which includes guiding our students, selecting good problems and setting suitable grading guidelines. Tutors and lecturers must still be prepared to discuss the assignment problems with our students. We must spend more time on concepts that cannot be effectively learnt online. It is also very important to integrate and build upon what the students have learnt from the online assignments. Our personal touch during class discussions or in the discussion forums is crucial as we want our students to know that we still care about their development.

We have continued to evaluate other systems that are available. Other publishers such as John Wiley and McGraw-Hill have also come up with their own online assignment systems, some of which have distinct advantages over MasteringPhysics in some areas. MasteringPhysics has the advantage of having a headstart in developing a Physics online assignment system and have built up a very strong database of problems and a feedback system which the other publishers have to compete against.

E-learning has slowly but surely gained a foothold in our teaching. While one must be open to the possibilities they offer, we must also not be blinded by them and exercise good judgment in our selection of materials and methods of delivery. Technology can only assist but not replace us, at least in any foreseeable future. It is still our responsibility as teachers and mentors to ensure that our students' time with us is meaningful and well spent.

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