

The Use of the MasteringPhysics System in First Year Physics at the University of Sydney During 2004

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Summary

MasteringPhysics is a tutorial system based on the First Year textbook “University Physics” by Young and Freedman (11th edition). The system is internet-based and “Socratic” in that it guides students through problems, adjusting its responses in accord with the student’s answers. The system allows both numerical and symbolic responses, making it valuable for many types of problem used in teaching physics. The system was introduced on a trial basis for a stream of First Year students at the University of Sydney during 2nd semester in 2004. It was used for six assignments and students were also encouraged to use MasteringPhysics as a private tutorial system. This report is a summary of the implementation of the system during 2004, the process used to monitor student reaction to it, and the outcomes of this monitoring.

Documents Forming Part of this Report

Document Name	Purpose
MasteringPhysics.doc	This document. Text and main body of the report
Characteristics of Class.doc	Graphs showing the general characteristics of the class as obtained from the end of semester survey
Computer Access and Experience.doc	Graphs showing student access to, and experience with, computers and the internet as obtained from the end of semester survey
August Focus Group Notes.doc	Notes from the Focus Group Meeting held in August
October Focus Group Notes.doc	Notes from the Focus Group Meeting held in October
MasteringPhysics and Problem Solving Comments.xls	The comments made by students about the value of MasteringPhysics in teaching problem solving skills. Obtained from the end of semester survey. File also contains a “rating” of the comment (used for further study) and also lists the final exam mark obtained by that student.
MasteringPhysics and Understanding Concepts Comments.xls	The comments made by students about the value of MasteringPhysics in helping the understanding of concepts in physics. Obtained from the end of semester survey and containing a “rating” of the comment (used for further study) and also the final exam mark obtained by that student.
MasteringPhysics and Technical Issues Comments.xls	Comments by students in the survey about technical issues encountered in their use of MasteringPhysics.
Distribution of Marks for MasteringPhysics and Paper.doc	Distribution of marks for MasteringPhysics assignments in Y2004 and for the paper-based assignments for the similar class in Y2003
Comparison of Student Performance in PHYS1001 and PHYS1003	Performance of the students who did both PHYS1001 (first semester) and PHYS1003 (second semester)

1. What is the MasteringPhysics System?

MasteringPhysics is internet-based system introduced by Pearson, the publishers of the “University Physics” which is the standard textbook for much of First Year at the University of Sydney. The system resides on the MasteringPhysics website (www.masteringphysics.com) and is accessed by students through the web. A login password is required and this is obtained when the textbook is purchased. Questions are grouped into three categories: “Skill Builders”; “Self Tutoring Problems”; and “End of Chapter Questions”. These include different types of problems in physics, ranging from a graded tutorial in a subject area, through to the traditional problem-solving and numerical evaluation. Only the End of Chapter questions are specific to the textbook.

MasteringPhysics responds in accord with student needs and responses. For many questions, there are hints that break the problem into sections that are more easily understood by the student. Access to these hints can result in an adjustment of marks available for that question. The system also allows multiple attempts at problems (the number being set by the lecturer) and offers useful suggestions when an incorrect answer is input, tailored to the nature of the incorrect response.

A clear strength of the system is the immediate feedback provided to help students arrive at the correct answers.

MasteringPhysics has a flexible marking system that allows lecturers to assign the loss of marks for incorrect answers, the number of attempts allowed at each problem, and the penalty for using the hints (or the bonus for not using them). The system allows questions to be grouped into assignments, marks to be allocated for each question, and a deadline set the assignment. This deadline can be “soft” as the maximum mark is reduced over a period after the deadline expires. The system tells students immediately the marks that they have obtained for each question or for the assignment as a whole. It also records the results in a class list which can be accessed on-line by the lecturer or downloaded for the grading process.

2. The Trial at the University of Sydney

The MasteringPhysics system was trialled during second semester of 2004 for the PHYS 1003 (Technological) course. This group consisted of approximately 250 students, mostly from science and engineering degrees. This group was chosen because problem solving is an important aspect of their course and the majority of these students would be expected to be familiar with the use of computers and the internet. They are therefore less likely to be affected by technical issues in the use of MasteringPhysics.

The system was used for six assignments, spaced at essentially intervals during the semester. The assignments included the subject areas of fluids (one assignment), electromagnetism (three) and quantum physics (two). Final grading for the assignments was done on a best five out of six basis with the resultant total mark being counted as 15% of the final subject grade. This contrasts with the previous paper-based assignments which counted as only 5% of the final grade. The increased value of the assignments was felt desirable as greater incentive for students to use MasteringPhysics diligently, representing a mark more closely proportional to the time spent.

Each MasteringPhysics assignment consisted of questions (usually four), that were worth a small number of marks as a tutorial followed by another four higher valued assignment questions.

3. Monitoring the Implementation of MasteringPhysics

Being a trial, it is very important to monitor the implementation of the system. To this end, a grant was obtained from SciFER and Richard Thompson was employed on a casual basis. His tasks included assisting with the implementation process and addressing student issues with the system. Most importantly, his tasks involved holding several focus group discussions, running a survey of student attitudes to the system, analysing the results of the survey, and reporting on the outcomes.

Students were encouraged to provide feedback on MasteringPhysics as follows:

- personal feedback at lectures and in practical sessions;
- email from students, either directly to lecturers via the MasteringPhysics or WebCT systems, or via a WebCT discussion forum;
- two focus group sessions (one early-mid semester and the other at the end of semester). Notes from these sessions are included in this report;
- a survey of student opinion, completed in the final laboratory session of the semester. A total of 128 responses were received (just over 50% of the class).

The comments in the rest of this report are based on this feedback from students.

4. Some Issues Arising from the Trial

4.1 Access to a Computer and the Internet

Access to a computer and the internet are essential for using MasteringPhysics. Such access can be obtained via the University Access Centres or, most usefully, via a home system. Assignment questions mostly require some time working out the answer on paper followed by entering the answer into the computer. Therefore, regular access is most appropriate.

The survey asked about access to a computer at home and the type of internet connection. The results indicated that 95% of students had access to a computer at home while 5% did not. The main type of access to the internet was via broadband (55%) whilst dial-up access accounted for 41% and 4% reported no access to the internet. Access via broadband was found to be much more common than in a small survey undertaken by John O'Byrne prior to the trial. This is consistent with a recent surge in broadband usage in Australia and this trend is likely to continue for the near future.

Despite the high availability of access from home, students reported in the survey a considerable use of University facilities with 20% using the facilities daily, 42% weekly, and 29% every few weeks. Only 9% reported as never using the facilities. Many of the uses of the facilities would be for purposes other than MasteringPhysics.

Despite the availability of home access for MasteringPhysics, lack of access is likely to be very important for a small number of people. The student with the most

negative view of MasteringPhysics at the first focus group meeting was most affected by poor access to the system.

4.2 Expertise in the Use of Computer and the Internet

The survey asked students to assess their level of competence in the use of computers and the internet. Whilst a somewhat arbitrary assessment, it was interesting that 96% rated themselves as either competent (69%) or expert (27%) in both of these areas.

4.3 The MasteringPhysics Environment

In general, students found the general environment of MasteringPhysics to be easy to handle. However, a number of issues were raised by the focus groups and survey.

The input of equations can be a bit difficult. For example, to enter a symbol “lambda” the word needs to be typed in full and spelt correctly. There were a number of student problems with the system that came down to spellings of “lamda” or similar! Also, entry of a value r_l is written as r_l, 10^3 is written as 10^3, e is 2.71... rather than an exponent as in for example Matlab, and (sometimes long) sequences of brackets must match. A tutorial, completed by students at the start of semester, covered these issues. It is then just a matter of students becoming familiar with the system. In later assignments, the use of the “Display Math” button was emphasised in the lecturer’s notes at the start of the assignment. This allows students to see that MasteringPhysics interprets their equation in the expected manner.

Rounding errors appeared to cause confusion at times. For numerical results, MasteringPhysics marks as correct a range of values around the precise result and then tells the user to use its value for any future calculation. There are claims by students of ‘correct’ answers being marked as incorrect. The author did most of the assignment questions prior to the students and did not find problems. The confusion may come from cases where MasteringPhysics gives results that are calculated to lower precision than your own (and then tells you to use its result). There may be confusion but MasteringPhysics seems to be quite generous in the range of values marked as correct.

A few errors were encountered in the MasteringPhysics problems. There was a question in the fluids assignment that had a wrong answer (the question did not make it into the assignment); a question missing a useful diagram; and a diagram of a photomultiplier with an incorrect number of dynodes in it. These were annoying problems but fairly minor (except the first if it were to have been included in the assignment).

The “Hints” in MasteringPhysics were mentioned frequently in the survey as a good way to step through a problem. The system was set up so that students received a small bonus mark if they did not use the hints. In general, they were better off using the hints, sacrificing the small bonus for the larger reward of getting the problem correct! For a few of the harder questions, students were advised in the introduction to use the hints.

There was criticism of some MasteringPhysics problems in that there was essentially just a mark for a correct answer and no credit for being on the right track. One

question in electromagnetism (“the inkjet problem”) was a particular problem because it required a detailed calculation followed by substitution of numerical values. It was very easy to make a minor mistake and lose all marks for the problem. This is an issue to be aware of when selecting problems for an assignment. Such “all or nothing” questions should be avoided.

4.4 MasteringPhysics Compared with Paper-Based Assignments

One primary feature of this trial was the use of a group of students who used paper-based assignments in semester 1 and could therefore make a personal comparison of paper-based and MasteringPhysics assignments.

Students were asked at the focus group meetings to compare MasteringPhysics with the paper-based assignments used previously. In general, students had no great love for the paper-based assignments as they did not provide a great deal of feedback. Only a half of the questions in a paper-based assignment are marked at all. The marking is generally of a tick/cross nature with occasional descriptive gems such as “bad physics”. MasteringPhysics gives immediate and detailed feedback.

One area in which paper-based assignments were superior was that the type of question asked in them is closer to that in exams. This is discussed in the next section.

4.5 MasteringPhysics For Tutorial Purposes/Exam Preparation

This was an interesting aspect to come out of the trial. Students in the survey rated MasteringPhysics more highly in helping them understand concepts in Physics than in helping them with problem solving. The difference between MasteringPhysics problems and the type of problem found in exams was also mentioned at both focus group meetings. This is an issue that will need to be addressed for any future use of MasteringPhysics. A number of options are possible: such as a few paper-based assignments, or use of the practice examination session in the laboratory to give students experience in exam-style questions. Of course we need to remember that we are trying to teach Physics and not “exam survival techniques”.

4.6 Cheating and MasteringPhysics

All systems for assignments are susceptible to cheating by students. For paper-based assignments, this is quite easy, hence the low value (5%) we place on paper-based assignments. In the case of MasteringPhysics, cheating is always possible when students pass on correct results to others. During the course of the trial we became aware that there were several fake “class members” who consistently scored very poorly. Evidently, a few students were using the fake identities to get MasteringPhysics to disclose the correct answers which were then input to their true identities. These fake identities were closed off quickly. They were possible because of the availability of a generic login provided to ensure everyone had access. This will not be available in any future use of MasteringPhysics, but it will still be necessary to monitor the use of the system to ensure fake identities via otherwise unused access keys are eliminated (and to close off any new logins early in the semester).

The second focus group was aware of cheating in the use of MasteringPhysics (although they were not specifically asked about the above system). Surprisingly,

they were not overly concerned as they thought that the benefits of cheating the system would be compensated by the reduced tutorial value of the system for those students.

When properly monitored, MasteringPhysics is probably less affected by cheating than paper-based assignments. However, a side issue is that MasteringPhysics can not be used to produce team assignments as has been encouraged at times. The reduced team work may itself be a loss in the educational process.

4.7 The Marking Scheme

MasteringPhysics has a quite flexible marking scheme. It is possible to limit the number of attempts that a student can make at a problem. This was set initially at four but after suggestions from students was increased to six for later assignments. There is a penalty for wrong answers which was set at 3% per section. This is a common value set by other people using MasteringPhysics and seems to give a reasonable benefit to those who get immediate correct answers. The “Hints” system on MasteringPhysics is very good. Students can either be rewarded if they do not need to use the hints or penalised if they do. In our case, a bonus of 3% was awarded for non-use of the hints. In practice, students were far better to ignore the bonus and use the hints. The marking of multiple choice questions was interesting. The maximum possible mark for a question fell as incorrect choices were made so that no marks were available when there was only one choice left. In effect, this meant that wrong answers for multiple choice questions could reduce marks significantly (more so that for other types of question).

MasteringPhysics gives immediate feedback on marks obtained for a question. Overall, no-one (staff included!) could really claim to understand the detailed application of the marking system. But neither the focus groups nor the survey comments really seem to be concerned about the system. The system is a bit of a mystery but it is basically fair.

4.8 Settings within the MasteringPhysics System

Aside from those to do with marking, there were a couple of other settings possible. Dates could be set for an assignment to become visible to students and a deadline established for completing the assignment. A useful feature was that the deadline could be ‘soft’ as the maximum possible mark was ramped down after the deadline expired. In our case, the maximum mark was decreased to zero over a period of 7 hours. This appeared quite popular with students according to the focus groups.

All times within the MasteringPhysics system are US-based. This is a bit annoying. It would be worth approaching Pearsons to see if this can be changed.

MasteringPhysics can be set to reveal or not reveal solutions (if students give up on a section or exhaust their maximum attempts). Initially, this was set to not reveal solutions with the idea that this discouraged cheating. However, this was quite unpopular with students as it resulted in an incorrect solution cascading to later sections. Instead of getting just one section wrong, the entire question was penalised (harshly). Following comments on WebCT and in the first focus group meeting, this setting was changed to allow solutions to be revealed. This seems to have been well received by students.

4.9 Technical Issues and Problems

The main technical problem mentioned by students in their survey responses (see document included with this report for full listing of comments) was a problem with the MasteringPhysics web server just before the deadline for one of the assignments. Fortunately, John O'Byrne was aware of the problem and extended the deadline for the assignment. Such problems are probably rare. But, it would be worth approaching Pearson to see if there is/could be an email system established to alert lecturers of any problems with MasteringPhysics.

Other technical problems were mostly concerned with the answer rounding issue, and the strict input format.

4.10 Resource Implications in Using MasteringPhysics

The following is a (very rough!) estimate of the costs of MasteringPhysics versus paper-based assignments. These are based on the current Physics 1003 class (for one semester) and it is assumed that some effort (such as the setting of assignments and production of solutions) is common to both forms of assignment.

Paper-Based Assignments

Activity	Estimate of the Cost
Marking of six assignments each with 250 manuscripts, including collection, distribution, marking, recording results, and associated administrative costs and on-costs.	6 assignments by 250 students by 0.25 hours by \$27 per hour equals approximately \$10,000

MasteringPhysics

Activity	Estimate of the Cost
Monitoring of MasteringPhysics system, answering student questions, and collating results. Charged at a 7 hours per week at a higher 'staff' rate of \$40 per hour.	7 hours by 13 weeks at \$40 per hour equals approximately \$3600

4.11 How the Survey Rated MasteringPhysics

The following is a summary of the results of a survey given to students in their final laboratory session. Details have been discussed either earlier in this report or are shown in a separate document.

Characteristics of the Class:

- Mostly in the age range of 18-20 years old;
- Predominately male (78%);
- From a mixture of schools (49% government; 31% private; 16% catholic; 4% other);
- 72% from Sydney region and a mixture from other areas in Australia and from other countries;
- 33% of students had two parents with a University degree; and 34% had one parent with a University degree;

- 79% of students had done Physics 1001; 10% had no physics background. Only 3% had done Physics 1901.

Computer and Internet Experience:

- 62% of the students use the University computing facilities weekly or more frequently (despite a high rate of internet access from home)
- 95% have access to a computer at home
- 55% have access via a broadband connection and 41% have a dial-up connection.
- 87% used the internet for University work either weekly or more frequently
- 96% of students described themselves as either competent (69%) or expert (27%) in the use of computers
- Similar percentages of students described themselves as competent or expert in the use of the internet.

Students were asked to comment on the value of MasteringPhysics for developing problem solving skills; for developing understanding of concepts in physics; for their general comments on the system; and for any comments on technical issues encountered whilst using the system. Spreadsheets containing their comments are included with these report documents.

A simple rating system (an integer from -2 up to +2) was established to classify these comments as: “significantly negative”, “negative”; “neutral”; “positive”; “significantly positive”. A “significantly -ive” rating was given when the comment contained expressive words such as “very”, “horrible” etc. Positive or negative ratings were given for more simple comments such as “Yes”; “I liked the hints” etc. A neutral rating was given when the comments contained a mixture of positive and negative comments. In general, there were few neutral ratings as students were asked for a definite comment. If no response was made to the question then the student was eliminated from the analysis for that question.

The students were also asked for their general comments on MasteringPhysics. The responses were largely similar to responses to the earlier questions on problem solving and on understanding concepts. There was also a larger number of “no responses”, indicating that there was nothing new to add. The “general comments” responses were rated but are not included in this analysis.

Richard Thompson, John O’Byrne, and Chris Stewart rated each comment. A combined rating was then obtained by rounding the average of the three numerical ratings to the nearest integer (all four rating are included in the spreadsheets of the student comments along with the exam result of the student). In practice, this meant selecting the two that agreed out of the three. In general, the three ratings agreed extremely well; the main differences being between the “significantly -ive” and the “-ive” categories. The polarity of the rating was almost always easy to distinguish.

Some outcomes from the analysis of student opinions are:

- A majority of students (71%) thought that MasteringPhysics helped with problem solving (55% positive; 16% significantly positive);
- A minority of students (26%) thought that MasteringPhysics did not help them with problem solving (18% negative; 8% significantly negative);

- A majority of students (79%) thought that MasteringPhysics helped them understand concepts in physics (67% positive; 12% significantly positive);
- A minority of students (19%) thought that MasteringPhysics did not help them with their understanding of concepts in physics (16% negative; 3% significantly negative);
- In each case, the percentage of neutral comments was quite small.

It is worthwhile to examine if there is a relationship between the opinion of students about MasteringPhysics and their results in the final exam. The responses were divided into two groups according to their opinion about the value of the MasteringPhysics system for understanding concepts in physics (the negative and significantly negative group; and the positive and significantly positive group). In each case, the exam results were binned and these graphs are shown below. A similar analysis was made for the “problem solving” comments and the results are very similar.

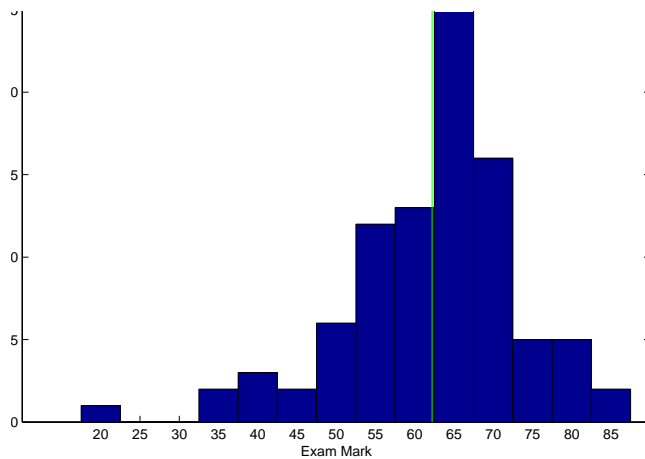


Figure 1: Exam results for students who liked MasteringPhysics

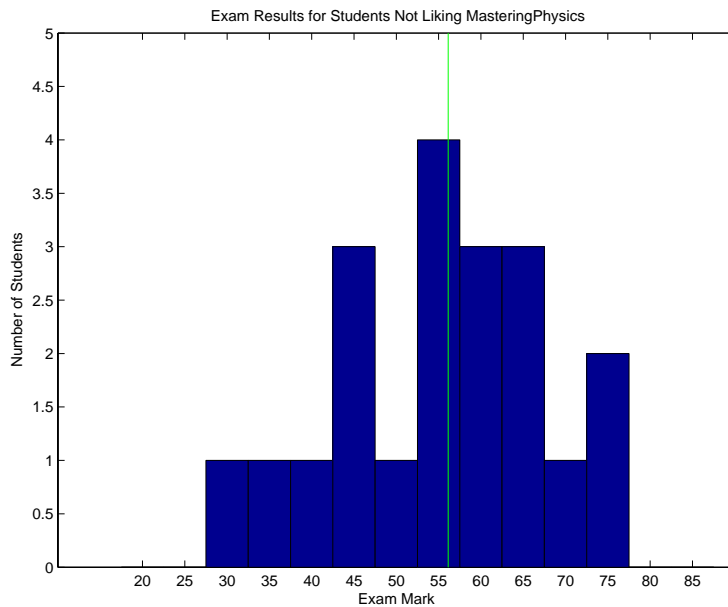


Figure 2: Exam results for students who did not like MasteringPhysics

In both figures, the vertical green line is the average mark obtained by the group (62.2 for those liking MasteringPhysics and 56.1 for those not liking MasteringPhysics). The number of students in the not-liking MasteringPhysics group is much smaller but in general MasteringPhysics seemed to have been liked relatively more by the better performing students.

4.12 Comparison of Exam Marks and Assignment Marks

The graph below shows a comparison of the assignment and exam components of the final mark for the students. There is not much correlation between the two. The obvious clustering towards high marks in the assignments includes a number of students who did poorly in the exam. Also, a few students did well in the exam component but not in the assignments (i.e. didn't really do them seriously).

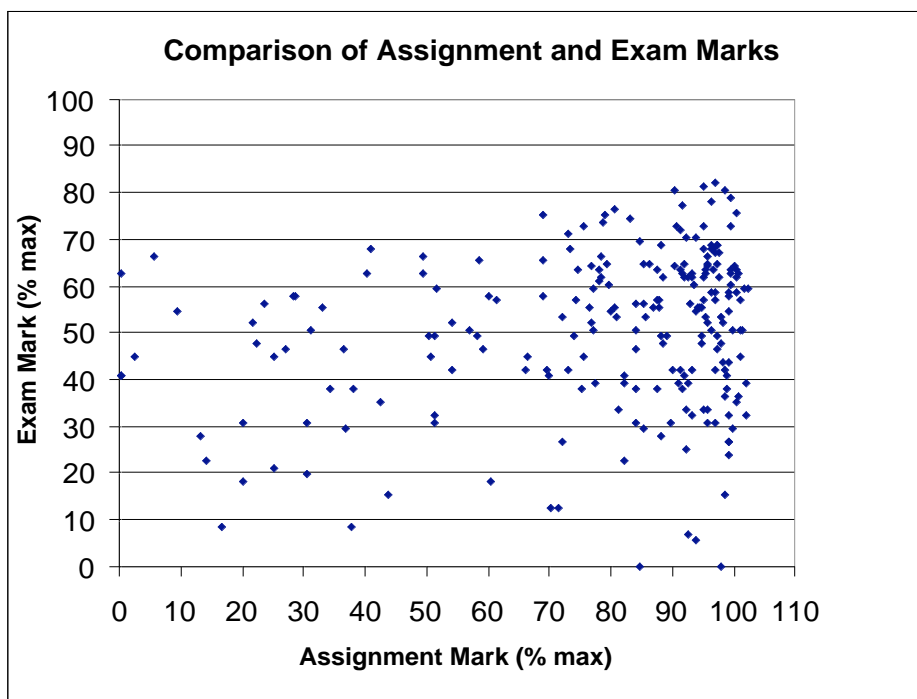


Figure 3: Comparison of final exam result and assignment mark (i.e. MasteringPhysics result) for students in the survey

It is worth comparing the results in Figure 3 with the equivalent class from the previous year (i.e. Semester 2, Year 2003) who did paper based assignments (which were worth only 5% of their final mark). This is shown in Figure 4.

A significant difference between the two years is that more of the MasteringPhysics marks fall close to the maximum possible value, even for students whose exam mark was quite poor (for more detail see document "Comparison of Marks for MasteringPhysics and Paper-Based Assignments" which forms part of this report). There are a few possible reasons for this. Firstly, there could be more co-operation between students (either legal or illegal!). Secondly, it could be due to the nature of MasteringPhysics itself. The system of hints, and the ability to try again several times after an incorrect answer, should work towards even mediocre students obtaining full marks if they are suitably diligent. It is not possible to rule out the first option; but if the second option is the case, then this is a very good feature of the MasteringPhysics approach.

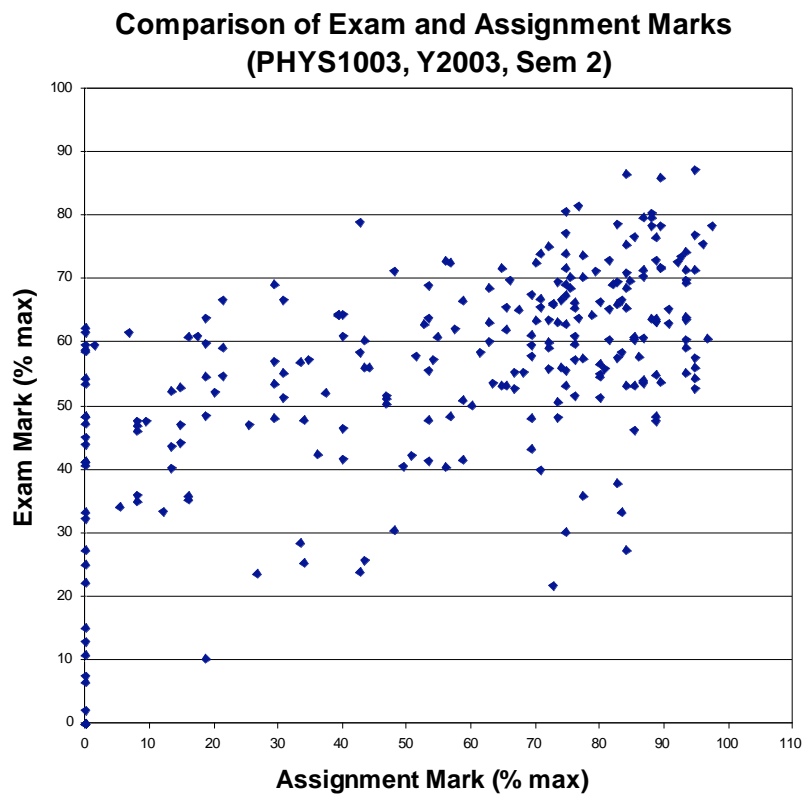


Figure 4: Comparison of Exam and Assignment Marks for PHYS1003 class in Semester 2 of Y2003. Assignments were paper-based for this class.

4.13 Comparison of Student Performance in First and Second Semesters

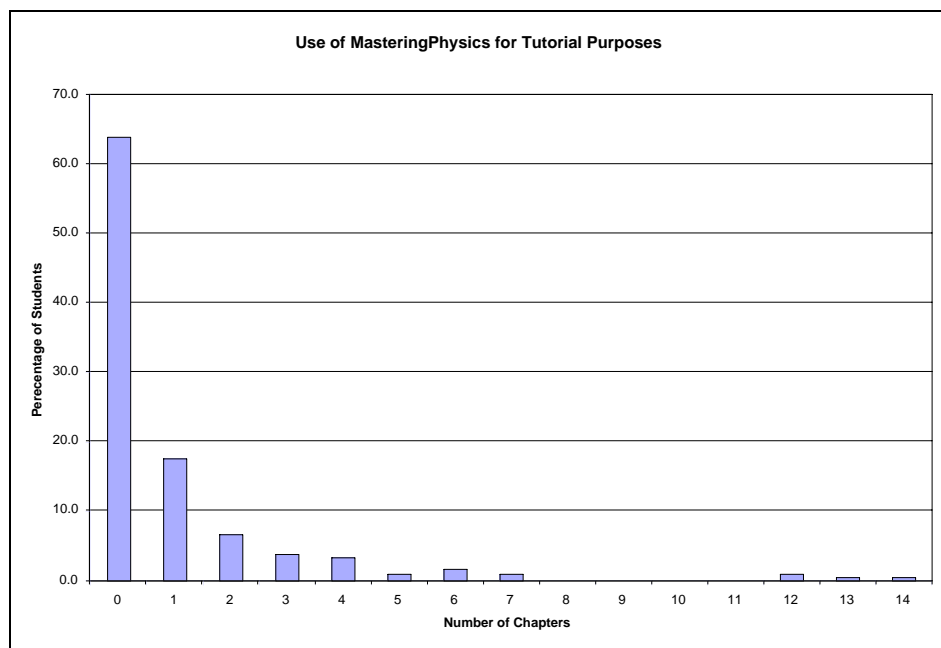
Many of the students who used MasteringPhysics in PHYS1003 also did PHYS1001 in first semester. This allows a comparison to be made between their performance in the exams in each semester and their performance in the assignments associated with both courses. In PHYS1001 this was a paper-based assignment whilst in PHYS1003 it was based on MasteringPhysics.

A more detailed study of the relationship between these four marks is given in a document forming part of this report. A summary of some of the findings follows:

- All four are reasonably well correlated. Best correlations are obtained between the two exam results and the two assignments.
- The MasteringPhysics results show a saturation in which the middle-to-good students tend to score close to 100% in MasteringPhysics. This is probably due to the structure of hints and multiple attempts in MasteringPhysics. If so, it is a good educational outcome because students are led to a correct answer, hopefully to learn.
- A number of students performed unexpectedly well in MasteringPhysics and this could be due to some form of co-operation, either legal or illegal.

4.14 Other Issues

This report has concentrated on the use of MasteringPhysics for assignments. However, a major benefit is that students may use it for their private tutorial purposes. All of the problems from each relevant chapter of the textbook were made available to students. The system kept a record of the student's use of these problems but they did not count in any way towards assignments or other marks. The graph below shows the percentage of the students doing problems from the 14 tutorial chapters available to them. The majority of students (more than 60%) did not use the system at all. In expectation of this behaviour, the low mark value "tutorial" questions were added to the assignments – to encourage them to see it as more than just an assignment system. Of those using the extra questions, most attempted only one chapter (usually the first!) and most attempted only a few questions from those on offer. An estimate is that approximately 10 students used the system for tutorial purposes in a serious manner.



5 Final Comments

The following is a summary of the views of the author about the trial of the MasteringPhysics system.

- From a technical point of view, MasteringPhysics performed well. There were issues such as: a web server failure; a few questions that could have been better; an environment where input of equations is (perhaps necessarily) tricky; and some confusion about the rounding of numerical results. But, on the whole, the system worked well. The system of hints and the immediate feedback was particularly popular.
- There was a range of student opinion from really liking it to really hating it. But a majority liked it, particularly because of it helping them to understand concepts in physics. There is evidence that the better students were more likely to like the system than the poorer students. Some of those disliking the

system may have done so because it exposed their weakness with physics rather than because of the system itself.

- There was no great love in general for the previous paper-based assignments because these provided little feedback to students.
- There is no doubt that MasteringPhysics reduces costs, although the savings made are mainly by reducing marking of paper-based assignments by casual staff and there is an offset cost in work probably done by permanent staff.
- The issue was raised that the type of problem in MasteringPhysics did not provide students with preparation for exam questions. This is a valid issue that requires some thought.
- MasteringPhysics was poorly used by students for their own private tutorial purposes. This was the case despite MasteringPhysics being of great potential benefit to them.
- The most important question of all is whether MasteringPhysics provided students with a better educational experience than the previous paper-based assignments. It is really hard to answer such a question objectively. But, my personal opinion is that it did. This opinion is based partly on “negative” issues such as: the previous paper-based assignments had quite limited feedback value for students; and the resources saved by MasteringPhysics can be used for student benefit in other areas. Partly, the view is also based on “positive” issues. The MasteringPhysics system is flexible, works quite well, and provides immediate feedback to students both in terms of the accuracy of their responses and the mark that they have obtained. It has even greater potential if students can be encouraged to make better use of it for private tutorial purposes.
- A wider application of MasteringPhysics in First Year would mean that many students would gain experience with it over two semesters rather than just one.
- The final word belongs to one of the students from the Focus group meetings. He described systems such as MasteringPhysics as the “way of the future”. This would be no justification for the continued use of a poor system but MasteringPhysics does work and will no doubt be improved progressively.