

Whiteboard Physics Tutorials Delivered Over the Internet

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Abstract: A traditional form of teaching in the classroom is for the teacher to define and solve a problem, writing the solution down on a chalkboard. Since the teacher can talk about the process of solving the problem whilst writing the solution out, the student has time to comprehend the solution method. However, this time spent is a disadvantage if classroom time is limited. Many teachers also rely on the method when engaged in one-to-one discussions with the students, and most faculty members at University level teaching institutions have some form of whiteboard/chalkboard in their office. We present a simple method of capturing the whiteboard tutorial in a media file, allowing the content to be played as often as the student wishes. The design, content and production process has been deliberately kept simple to minimize the preparation time required by faculty and media technology staff.

Introduction

The requirement for this pedagogical tool stems from one of the author's (AWR) teaching load, which includes two classes of first year University general physics, with relatively large class sizes, up to 400 students in total. Most University level teachers would agree that one-to-one interaction with the students, working out problems at a board is a highly valuable pedagogical tool, and some Universities (Oxford and Cambridge, in the U.K., for example, base a significant amount of their undergraduate teaching effort around the "tutorial"). However, in most institutions of higher education, the staff to student ratio precludes giving every student this learning experience, which is a significant aid to student comprehension and retention of material. The syllabus of the algebra-based Physics course at the University of Saskatchewan (Physics 111) is relatively ambitious in terms of the content covered. This means that the number of worked problems which can be carried out in class is strictly limited, if a discussion of the basic principles is also required.

Some form of tutorial which could be prerecorded and replayed over the internet was therefore deemed to be desirable. Obviously this loses the interactive question-and-answer element possible in a true tutorial where the student and teacher are both physically present, but it does have the significant advantage that the tutorial can be replayed as many times as the student deems it necessary, thus allowing the lesson to proceed at a pace dictated by

the student. Moreover, these lessons can be used as teaching material for distance learning students. A trial by a school in Inner Mongolia is underway.

One important pedagogical aspect of this type of tutorial is that it exposes the student to the problem solving methods used by experienced physicists as early as possible in their science education at university level. As Knight (2002) has pointed out, experienced physicists formulate a model in order to solve a problem, followed by application of relevant physical principles and boundary conditions to reach a solution. This method is not used by most inexperienced students, who use the “hunt for a relevant equation which has the right variables in it” approach, which is often successful at the high school level. Van Heuvelen (1991) has demonstrated that the expert physics approach is not fully developed until graduate level work in physics is being undertaken. It is therefore highly desirable that these tutorials demonstrate the “expert” technique of problem solving to the students, so that good problem solving skills as advocated by Hestenes (1987) are developed as soon as possible.

Implementation

When implementing the whiteboard tutorials there were two important criteria which had to be met. Firstly, the files produced had to be relatively small to minimize download times. Saskatchewan is fortunate to be served with a relatively complete coverage of high speed internet access, so it was deemed necessary for files to load within a few seconds over a typical household feed. Secondly, the production process had to be relatively straightforward, requiring few people and few production steps from recording to the mounting of the files on the fileserver.

In order to reduce the file size, it is necessary to simplify the video image as far as possible. In order to minimize the changes on the screen it was decided not to have a full video picture of the teacher giving the tutorial, but to record a voice-over track and have a white screen on which the problem is displayed. This reduces the video image shown to essentially a white background with relatively slow changes to black, as the problem is solved, which makes the image highly compressible. A further advantage is that the teacher is not a distraction to the eye and cannot obscure the work being done on the Smartboard, unlike a traditional tutorial session.

The inspiration for having the writing appear on the screen without the picture of the professor comes from television programs such as “Art Attack” (The Media Merchants Television Company Ltd). In this type of program, the shots of art or craft work show only the hands of the artist, with a voice over in the appropriate local language. This technique means that scenes do not need to be re-shot when selling the program into different language markets. Many of today’s students will be familiar with this type of shot and so the concept of not seeing the professor on screen is not a novelty. We note that informal feedback from an audience of professors, who had been shown the whiteboard clips, to one of the authors (DM) suggests that the “more mature” members of the profession would like to see a full video of the presenter. We intend to investigate this difference in perceptions when we conduct an end of year survey of the students using the tutorials.

When preparing these tutorials, a batch of four or five problems is devised per recording session. The preparation time for the faculty member is approximately two to three hours, being roughly comparable to the time taken to set a weekly assignment. The recording of each batch then normally takes one hour. To make this type of recording we used a large sized Smartboard (Smart Technologies, Canada), running Smartboard Software (version 9.5.48.1). This allows the teacher to write directly onto the touch screen surface with special pens. To capture the input in real time, we used Camtasia version 4 (TechSmith Corporation, USA). This allows screen capture of the evolving video image and simultaneous audio capture using a radio microphone (Sony Corp., Japan). The net result of this is that the teacher is solving a problem at a whiteboard which records the pen strokes and the audio commentary in real time. As this is a familiar situation to many faculty members, very little training is required, although we find that having a second person acting as the “director” is useful to make sure that the screen capture and audio are switched on or off at the appropriate time and that sound recording levels are correct. We find that a useful technique is to cut and paste the text of the problem to the top of the whiteboard screen, so that the recording begins with a voice over of the problem and if necessary further explanation or amplification of the problem solving technique. We use the following example, concerning the calculation of the final velocity of a coconut falling from a coconut palm tree. This event has been shown by Barss (1984) to cause severe trauma.

Before the recording starts, we set up the whiteboard input screen with the question cut and pasted from a word processor document into a text box on the whiteboard screen (Fig. 1). The University of Saskatchewan watermark background is added later in post production.

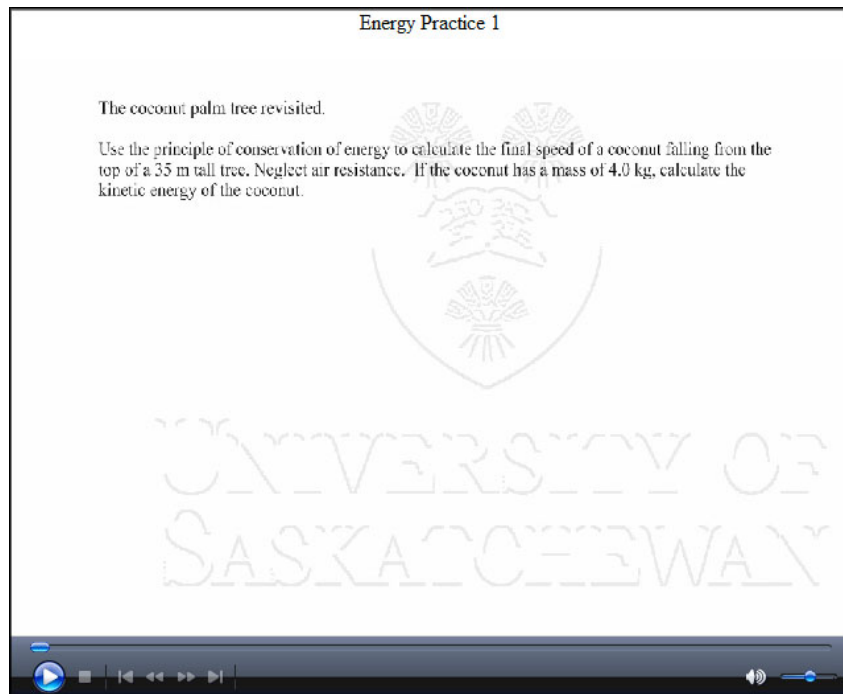


Figure 1: Initial view of the whiteboard before recording starts

At this point we begin screen capture and audio recording with Camtasia.

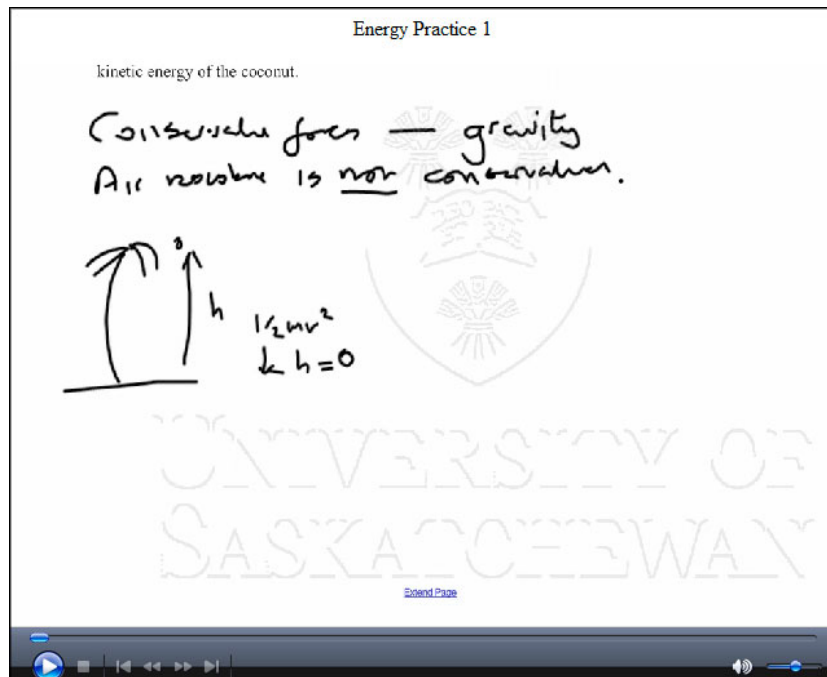


Fig 2: Setting up the solution with a sketch

The tutorial begins with a reiteration of the problem, including an explanation of the method of solution for maximum effect. We then begin the solution by making a sketch of the problem, to allow the student to visualize the problem, which assists in helping them see the method of solution required. The problem is then solved in a pedagogically rigorous manner (see Fig. 3), writing on the screen appearing in synchronization with the voiceover audio commentary.

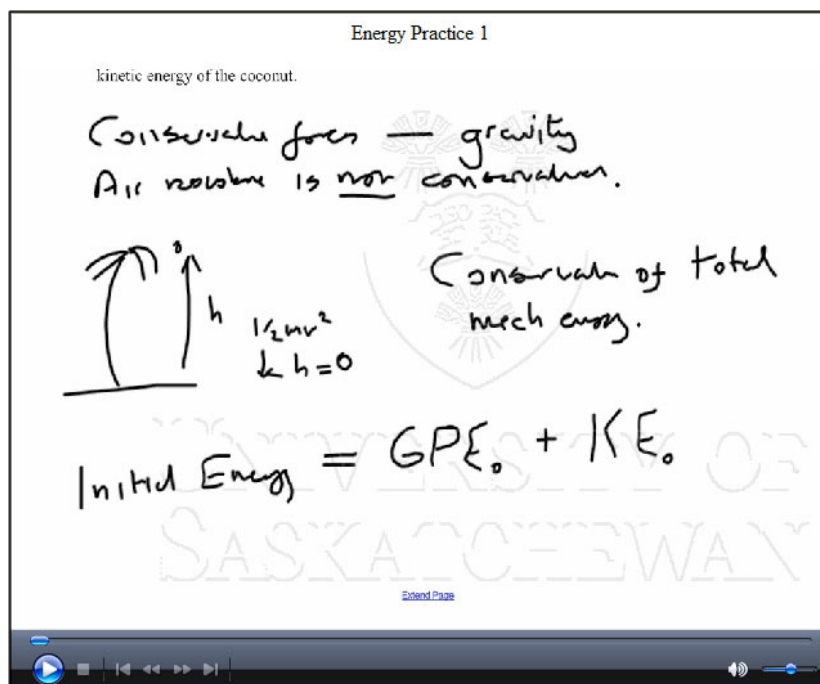


Fig 3: Solving the problem on the whiteboard

Note that the original problem gradually disappears from view during the writing of the solution, because of the scrolling of the whiteboard screen. We intend to address this shortcoming by redesigning the web site on which the video clips are displayed.

Post-recording Production

The Camtasia software allows the export in a variety of commonly used formats. In the present study we have been using WMV files, as the file server available at the University is optimized to deliver Windows format media files. Post-production is done within the Camtasia software which provides a relatively simple interface. Since the presentations were short, most of the post-production involved basic edits to ensure sound levels were appropriate and minor audio defects were corrected. The University of Saskatchewan watermark background was also added at this stage. It should be noted that Camtasia offers many other possibilities in the post-production process such as: adding an additional audio track, callouts, pan and zoom capabilities, a quiz track and close-captioning. None of these elements were added to the tutorials at this stage in the development although the ability to embed multiple choice and short answer questions may be looked at in the future. Each tutorial averaged about five minutes in length and required approximately 10 – 15 minutes to prepare within Camtasia. Once the simple edits were completed the Camtasia file was exported in WMV streaming format and the WMV files added to a custom designed web page. The average time taken to complete this whole process was about one and a half hours for a batch of five five-minute tutorials.

The files are then mounted on the University media server and are accessible to the student population and the general public through a web-site (Robinson et al. 2007). Access and loading times for the various clips are excellent when using the main campus network, and load in a few seconds when viewed at home using a high-speed internet connection through the local cable-television providers. The latter case is very important, because we want

our students to be able to view the tutorials from anywhere, not just on campus. At present we find that WMV files are best viewed with Microsoft Internet Explorer (version 7.0.5730.11) with the WMV plug-in. The current version of the Firefox Browser (version 2.0.0.3) browser appears to be unable to play the WMV video clips without cutting off the right hand side of the video image. The choice of another video clip format might mitigate these problems. To follow the example of the falling coconuts described in this paper, go to the whiteboards internet site (Robinson et al. 2007) and select the tutorial "Energy 1" in the "Work and Energy" folder on the left hand sidebar. We have also provided a video recording in WMV and Quicktime formats to demonstrate the making of one of these clips. These are accessible from the main page of the site.

The typical single tutorial problem lasts for 5-6 minutes and the average file size in WMV format is 2.2 Mb. We note that the video demonstration clip, which includes video footage of the professor at the whiteboard has a file size of 9.7 Mb for a WMV clip of 5 minutes and 44 seconds duration. The file size is considerably reduced when showing only the whiteboard and not the whiteboard and professor. This will naturally lead to shorter download times

Future Developments

We have developed the website to cover approximately half of the topics covered in the 2 semester Physics 111 syllabus. This was achieved with a shooting schedule of 2 recording sessions every 3 weeks. Faculty time constrains were the main reason for not shooting more footage. We intend to have a complete set of video tutorials ready for the start of the academic year 2007-8. In addition to increasing the quantity of the content of the site, we also intend to pursue other developments to improve the usability.

One development we intend to pursue is to produce a multiple view on the web based interface, so that we can keep the original problem in view at all times, while the video clip of the solution is playing. This will not require any changes to the content of the video clips, but to the website on which the clips are displayed. Informal student feedback has already made this a priority modification.

The Camtasia software also allows the creation of much more sophisticated teaching tools, such as the ability to create a tutorial with embedded questions and export the Camtasia file with the option of enabling SCORM 1.2 compliance. This creates a module that can then be loaded into a Course Management System such as Blackboard. When a student works through the tutorial and answers all the embedded questions the results are automatically added to the grade book in Blackboard. This could provide some of the interaction and feedback that instructors could not achieve in larger classrooms thereby expanding their teaching effectiveness. By focusing the embedded questions on key concepts, key steps in a process and/or sequencing lessons so that students would be required to enter a variable or factor at that stage in the formula development this could be a significant step forward in utilizing this technology to teach students in ways unavailable even a few years ago. These developments take the use of the whiteboard tutorial beyond the scope of the original idea for a quick-to-produce pedagogical tool.

Another application of Camtasia is to make relatively simple animations, created in PowerPoint, into video clips. This has been used very effectively by O'Day (2006) for biological and biochemical processes. However we note that the PowerPoint animation facilities are a little limited for physics use, as the motion of objects does not proceed at constant velocity, which is essential if some kinematics and dynamics problems are to be animated. The advantage of using PowerPoint animations is that they are very simple to produce and do not require a steep learning curve of more sophisticated animation systems such as Flash.

Conclusions

We demonstrate the production of simple tutorials which can be recorded by teaching staff on a whiteboard to supplement classroom teaching. These tutorials are not onerous or time consuming to produce, averaging 2-3 hours of teaching time, one hour of recording studio time and one and a half hours of post production time for a batch of five five-minute video clips. The clips have relatively modest files sizes, on average 2.2 Mb for a clip of 5-6 minutes duration and so can be streamed easily over high speed internet links, allowing students to study at home. This is work in progress and we intend to further develop and refine our presentations when a detailed survey of student experience with the tutorials has been evaluated at the end of the academic year 2006-7.

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Acknowledgements

We would like to acknowledge the contribution of Adam Katzman-Beimuts for testing the problems and pointing out and correcting several errors.