ENCOURAGING STUDENTS TO INTERACT WITH ANGULAR QUANTITIES

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Abstract

An interactive multimedia module in rotational kinematics has been completed at Edith Cowan University for first year physics students. In this second version, highly interactive testing pages have been added to help students improve their conceptual understanding of angular position, angular velocity and angular acceleration. Other pages have been revised and an on-screen calculator added to predict type pages. Students find the interactive testing pages useful and believe the module improves their understanding of rotational motion.

Keywords

rotation, kinematics, motion, physics, simulation, interactive, multimedia, concept

Introduction

A rotational multimedia module was created at ECU (Edith Cowan University) for use in the first year physics program. It allows students to explore concepts in rotational motion through the motion of the rotating blades of an interactive wind generator. An early version (or version 1) of the module was described and evaluated in a paper presented at ASCILITE99 (Swan, 1999).

However the module presented at ASCILITE99 was not a finished product. There were insufficient funds to complete some sections or include some planned features. In addition, it was found that students did not use the module in the way intended. They focussed on aspects of the module where they could gain practice in solving problems of a mathematical nature rather than interacting with the core concepts on the more interactive play pages.

A faculty teaching and learning grant of $5000 has allowed the module to be finished and made more interactive. The module (version 2) was completed in December 2000, and was trialed with students in semester 1, 2001. After a brief overview, substantial changes made to produce the second version will be described and some student responses discussed.

Module Rationale and Overview

In this section a brief rational and overview of the rotational motion module is given. The general layout (and much of the content) of the first and second versions of the module are similar and only the salient points are repeated here. The reader is referred to Swan (1999) if a more complete description of these parts is required.

In teaching rotational kinematics, popular first year university textbooks (Halliday, Resnick & Walker, 1997; Serway, 1996) make strong use of analogy between familiar linear quantities and the corresponding and less familiar analogous rotational quantities. Unfortunately, there is a wealth of evidence (Arons, 1996) that too many students at this level do not have correct conceptions of these linear variables, and for these students this methodology cannot be expected to succeed. An

interactive multimedia approach provided a unique opportunity for students to gain concrete experiences with rotational variables through the use of simulations rather than more abstract experiences through analogy. Financial support of $20,000 was granted by ECU to develop the first version of a rotational motion interactive multimedia module (Swan, 1999).

The module was created using Macromedia Director and is able to run on both PC and Mac platforms. Central to the module is an interactive simulation of the rotating blades of a wind generator through which angular concepts are explored. The equivalent of a Pentium III PC (with 64 MBytes of RAM) or higher is recommended to ensure smooth simulations of rotational motion.

The module was designed with an open architecture to allow for different learning needs and styles. After a short introductory sequence, students have the freedom to choose on which topic they start, and what pages they subsequently access. The content is divided into five topics:

1. θ Angular position (and displacement)
2. ω Angular velocity
3. α Angular acceleration
4. v,a+s Linear variables (and their relationship to rotational variables)
5. = Rotational equations (kinematic)

Within each topic, students can access up to three distinct types of pages. *Play* pages provide opportunities for students to get a 'physical feel' for the rotational quantities. Diagrams and/or simulations support the topic content on *theory* pages. Students can apply and test their knowledge on the *predict* pages.

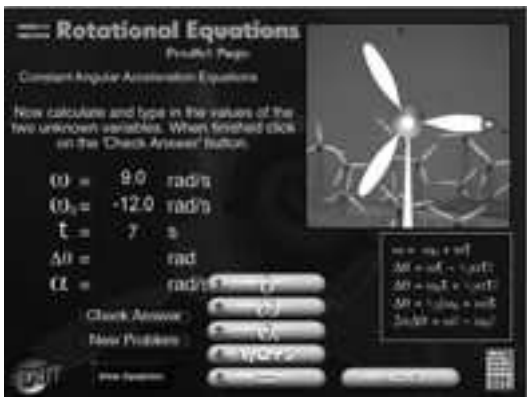

Figure 1: Angular velocity play page *Figure 2: Rotational equations predict page*

The play page for angular velocity is shown in Figure 1. By sliding the bar, students can vary the value of the angular velocity and immediately see the affect on the rotating blades of the wind generator. In using the first version of this module (Swan, 1999), students were found to spend far more time (a staggering 43% of their total time) on just one page; the rotational equations predict page. This page (with modifications) is shown in Figure 2, and provides students with practice in solving problems using the kinematic equations for constant angular acceleration.

Innovations and New Features

Funds from the teaching and learning grant allowed us to complete unfinished sections, make minor corrections, and generally reorganise and revise some of the pages after student feedback. Figure 2 shows some of the new features included in the second version of the module that were originally envisaged for the first. Students can now display the kinematic equations and on-screen calculator thus providing the necessary tools on-screen to solve the problems. On a PC the on-screen calculator is the Windows 95/98/2000 calculator. The topic navigation bar is also numbered

from 1 to 5 to provide guidance in the form of suggested topics. The feedback given for incorrect answers has also been expanded.

The major innovation is the creation of four interactive testing pages in which the rotational motion simulation is central to the testing. These four new pages are shown in Figures 3 to 6.

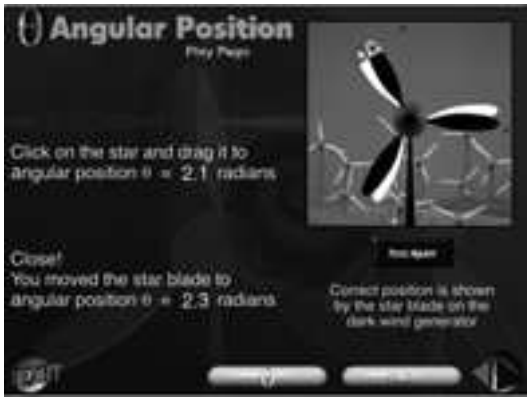

Figure 3: Angular position interactive testing play page

Figure 4: Angular velocity interactive testing play page

Figure 5: Angular velocity interactive testing predict page

Figure 6: Angular acceleration interactive testing predict page

In these new pages students can test their ability to link angular quantities with the actual rotational motion. In the play pages, students are tested on whether they can adjust the simulation to produce the rotational motion corresponding to a given value for angular position (Figure 3) or angular velocity (Figure 4). In the second predict pages, students watch the rotational motion, and then estimate the value of the angular velocity (Figure 5) or angular acceleration (Figure 6). Appropriate feedback is given on closeness of the student's estimation.

The level of interactivity with the core conceptual topics (angular position, angular velocity, and angular acceleration) has been substantially increased with the creation of these four interactive testing pages (Figures 3 to 6) that require higher level thought processes than the original *play* pages (e.g. Figure 1).

Evaluation and Discussion

The module was evaluated by eight volunteers from SCP1111 Physics of Motion in the week after the rotational motion had been covered in lectures late in semester 1, 2001. Students were each allowed up to 40 minutes with the module. They were also asked to take identical conceptual pre- and post-test, as well as completing a module evaluation. I sat behind the students and recorded the pages accessed and other notable events. The preliminary results are presented here.

Most students used this second version of the module in a similar way to the first version. While the addition of new interactive pages encouraged them to spend more time developing their conceptual knowledge, they still preferred to spend a large component of their time undertaking the mathematical exercises on the rotational equations predict page (see Figure 2). The new features ("Show Equations" and the on-screen calculator) were used extensively on this page.

Students overwhelmingly believed that each of the four new interactive pages were useful to them, and one student (who was the only very weak student) spent almost twice as much time than average on these pages. This student showed a dramatic conceptual test score improvement from 10% in a pre-test to 80% in an identical post-test. It was fascinating watching this student progress through these pages, making common mistakes, referring back to previous pages, and then slowly and methodically getting it right! I believe that this module will be very instructive for weaker students.

In evaluating the module, students were divided however on whether it was clear what should be done next. This is not unexpected given the open architecture for accessing the 20 topic pages of the module. Students did unanimously agree that the content was pitched at the right level and that their understanding of the content had improved. When the analysis of the data is complete, it is probably that a strategy for guiding students will be implemented for students using the module in 2002. This could include encouraging students to check their conceptual understanding on the interactive testing pages before progressing to other parts of the module.

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Acknowledgments

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