

## **INTERACTIVE MULTIMEDIA LABWARE FOR A TORSION EXPERIMENT**

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Abstract - A CD-ROM based laboratory manual for the torsion experiment in the Strength of Materials Laboratory was developed through collaboration between Civil Engineering and the Interactive Multimedia Department. The labware is intended to enhance student learning through the development of and exposure to richer learning tools, resources, and advanced technologies.

The pedagogy promoted by our approach is to engage students in active learning. The approach is to develop an interactive multimedia program for the laboratory component of the courses, which in turn strengthens the bridge between application and classroom theory. For laboratories equipped with the appropriate equipment, the labware is designed with the expectation that students review various aspects of the CD at different stages of the learning process. Prior to attending laboratory, students will be expected to review the basic concepts of the theory and to experience a “virtual lab” prior to their hands-on experience. After the experiment, students can use the labware to understand data reduction and data analysis in addition to accessing additional sets of experimental data. This additional data can include data from the same material measured in the laboratory in order to understand statistics or data resulting from varying parameter conditions. In the case of equipment failure or poor experimental controls and/or data collection by the students, the additional data will allow students to complete data reduction and data analysis critical to the link between theory and application of the experiments. For laboratories that do not have access to state-of-the-art equipment, the students can still investigate and link the theory, experimental methods, data collection, data reduction and data analysis.

### **I. Introduction**

Strength of Material is a second-semester sophomore or first-semester junior level engineering class, and is required for all civil engineering majors, as well as most other engineering majors. The

laboratory component of this class usually includes a torsion experiment. At Southern Illinois University Carbondale, the torsion experiment is conducted on a Tinius Olsen Torsion Testing Machine (10,000 in-lb. Capacity). The experiment consists of “twisting” a metal bar until it breaks. Measurements of the angle of twist and the torque are recorded. The linear portion of the data can then be used to determine the shear modulus of elasticity (G). Ideally, the students should test different materials (e.g. steel, brass, aluminum), different lengths and different diameters.

The labware (laboratory courseware) was designed to present elements of theory, experimental procedure, data collection, data reduction, report writing and statistics. To accomplish this, the labware combines text, illustrations, photographs, video-clips, sound, simulations, animations, hypertext descriptions, and hot-links to the internet, making it truly multi-media. The final product is published on a CD-ROM, with portions of the material available on the World Wide Web. This format provides the opportunity for incorporating many novel aspects into the labware. The long-term goal of the project is to use the style and approach developed on this project as a template for the other experiments in the Strength of Materials laboratory, as well as other civil engineering laboratory courses. Common elements to all of these laboratories include modules on laboratory safety, report writing, statistics and unit conversions.

The labware has potential use in a diverse range of university environments. The pedagogy promoted by our approach is to engage students in active learning, and to accommodate various learning styles. By focusing on the development of an interactive multimedia program for the laboratory component of the course, the labware can strengthen the important bridge between application and classroom theory. For laboratories equipped with the appropriate equipment, the labware was designed with the expectation that students review various aspects of the CD at different stages of the learning process. Prior to attending laboratory, students are expected to review the basic concepts of the associated theory and to experience a “virtual laboratory” prior to their actual hands-on experience. For laboratories that do not have access to state-of-the-art equipment, the students can still investigate and link the theory, experimental methods, and data collection.

## II. Background

Multimedia applications represent the best application of modern technology to education and training in all areas. It can be very cost effective and increase retention rates dramatically [1]. Computer technology and multimedia applications are particularly relevant in engineering education [2- 4]. They give students the opportunity for self-paced learning in an interactive environment [5, 6]. The format is nonlinear; allowing the student to review certain parts in a manner that is much easier than with simple videotapes or audiocassettes.

The effectiveness of computer-based instruction has been widely documented in numerous studies. These results are summarized in three survey papers [7 - 9]. Web-based classes have been also proven to be effective [10], allowing class time to be spent in other ways [11]. Multimedia instructional modules tend to engage students in active learning [12, 13], which is very important in modern educational theory [14]. Even non-technical topics such as communication skills have been successfully addressed by multimedia instruction [15]. Distance education is another area where multimedia applications are very appropriate [16]. Student acceptance and usage of educational multimedia is high [17].

There has been a significant amount of work done in the area of multimedia and/or web based interactive learning modules in science and engineering. This work ranges from basic courses such as physics [18], statics [19, 20], dynamics [21], thermodynamics [22], strength of materials [23], and engineering economy [24], to advanced topics such as finite element analysis [25]. One area that has received considerable attention is manufacturing with some work done on laboratory applications [26, 27] and other work on using multimedia simulations to teach design [28]. Some work has also been done in the area of environmental engineering [29 - 31].

The topic of trying to supplement or replace basic engineering laboratories has also been studied. The concept of virtual engineering laboratories was introduced for electric circuits at Vanderbilt in a paper by Mosterman et al [32]. Simulations in manufacturing process laboratories and manufacturing design have been presented by Hailey and Hailey [27] and by Riggs et al. [28]. In the Civil Engineering area, Alani and Barnes discussed the development of a multimedia soils mechanics laboratory [33]; and the paper done by Kantz et al. [31] looks at some aspects of an introductory environmental lab.

### III. Program Overview

The program starts with an introduction screen as shown in Figure 1. The main menu screen as shown in Figure 2 follows this. A different image appears when the cursor hovers over each item on the list.

The Theory Section was subdivided into three subsections: Strain and Displacement, Stress, and Plastic Behavior (Fig. 3). Within each of these subsections, the user is presented with three options for reviewing information: a WORD document can be downloaded and opened in a word processor, an html version of the document can be viewed in a browser such as Netscape, or the text can be viewed in the current application (Fig. 4). Other sections have similar options.

The Experimental Procedures item on the menu provides a menu as shown in Figure 5. This is the entry into the innovative section of the application. The various choices in the resulting menu open screens that will play a video clip with sound that will demonstrate some aspect of the experiment, such as operating the equipment as shown in Figure 6, preparing the specimen, or actually performing the experiment as shown in Figure 7. In addition, there is an added option for students to take notes. Clicking on this icon brings up Notepad®, which is available on all computers using Windows®. Playing the videos requires QuickTime® software, which is available for free on the Internet. This software is also included in the CD so that a user will at most have to install it on their computer. While the sound track is helpful, the pertinent information is also provided in a text-based screen that is synchronized with the film clip. This allows the CD to be used on computers that do not have sound cards or speakers. It is felt that many PC labs do not currently have sound due to space and budget limitations, as well as by choice. It is important that this application be useful on as wide a variety of platforms as possible, while simultaneously taking advantage of as much modern technology in the multimedia area as possible.

Some of the menu items represent links to areas that have not been completed. For instance, a database was developed by conducting the experiment on four different materials (steel, cast iron, aluminum, and brass), for two different lengths (6" and 8") and three different diameters (3/8", 1/2"

and 5/8"). Numerous sets of data for each of these combinations have been measured, and are stored on a database. Eventually, students will be able to randomly access this data. As a result, students will be able to perform statistical analysis, conduct a virtual laboratory when equipment is unavailable, or conduct a comparative study, with each student potentially having a unique set(s) of data. This will further enhance the student's understanding of data reduction, data analysis and statistical analysis of real-world data.

#### IV. Assessment

The program was tested using in a small focus group of 24 students and faculty. Assessment was performed through a questionnaire. Each question throughout the survey was marked according to a 7-point Likert scale where a value of 7 indicated the highest possible positive response, and a value of 1 indicated the lowest or most negative. When calculating the totals, a value of 168 is the highest possible, whereas a value of 24 would be the lowest possible. The results are divided into three categories, as shown in Tables 1-3. Overall, the project received favorable reviews.

#### V. Summary

A CD-ROM based laboratory manual, or labware, was developed in collaboration between faculty in the College of Engineering and the College of Mass Communication. The project presented is the template for additional material, which will include other experiments in Strength of Materials, as well as other Civil Engineering laboratories. The final product can potentially serve as a national model for Civil Engineering laboratories. Portions of the project can be viewed in html at [http://civil.engr.siu.edu/Strength\\_lab/torsion.htm](http://civil.engr.siu.edu/Strength_lab/torsion.htm).

Table 1. Overall evaluation of the project

Question	Low	High	Total	Average
Contributed to user's understanding of procedures	4	7	152	6.33
Contributed to user's understanding of theory	2	7	146	6.08
Helped prepare user for experiments	5	7	158	6.58
Project seemed to maintain user's interest level	4	7	146	6.08
Would like to see CD-ROM included in future	7	7	168	7.00

Table 2. Evaluation of Production Elements

Question	Low	High	Total	Average
Use of video clips helpful	5	7	159	6.63
Use of text to follow navigation helpful	4	7	142	5.92
Use of spoken narrative helpful	3	7	147	6.13
Use of 3D-animated video segments helpful	4	7	148	6.17
Choice of graphics helpful	5	7	155	6.46

Table 3. Evaluation of Interface

Question	Low	High	Total	Average
Interface easy to navigate	4	7	146	6.08
User felt confident/in control while navigating	4	7	142	5.92
Information presented in an organized way	5	7	155	6.46

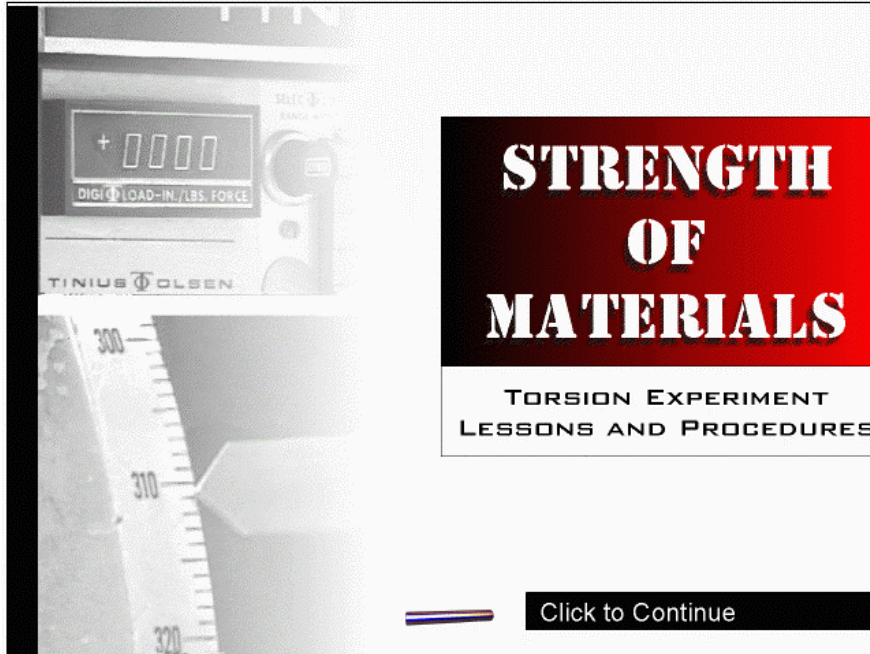


Figure 1. Introductory Screen for Application

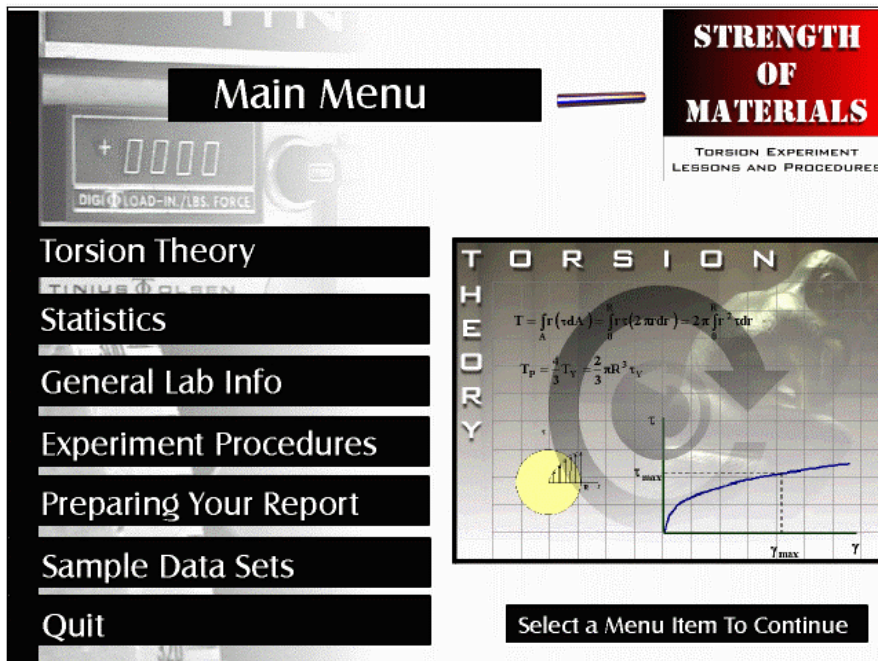


Figure 2. Main Menu for Application

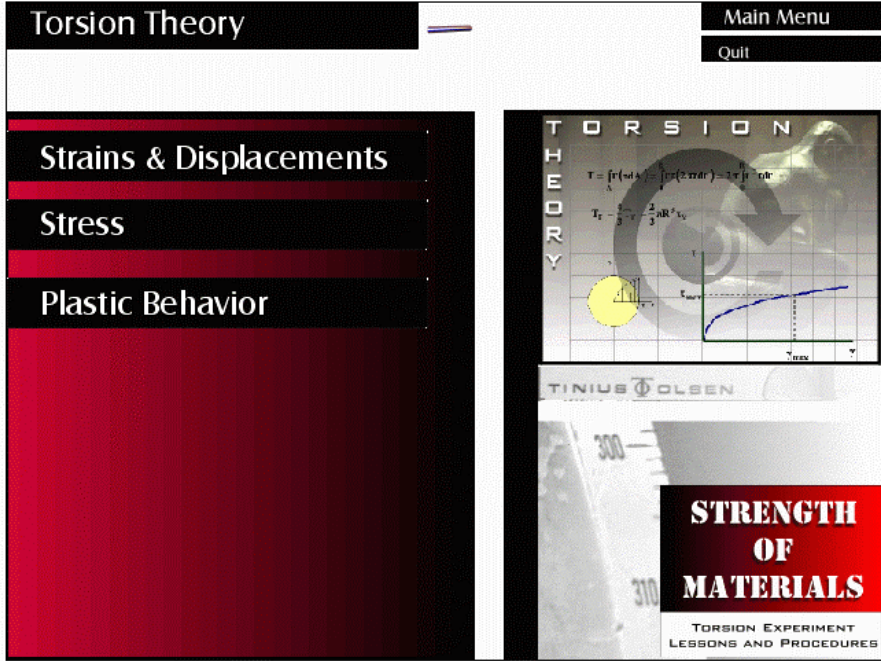


Figure 3. Subsection of the Torsion Theory Section

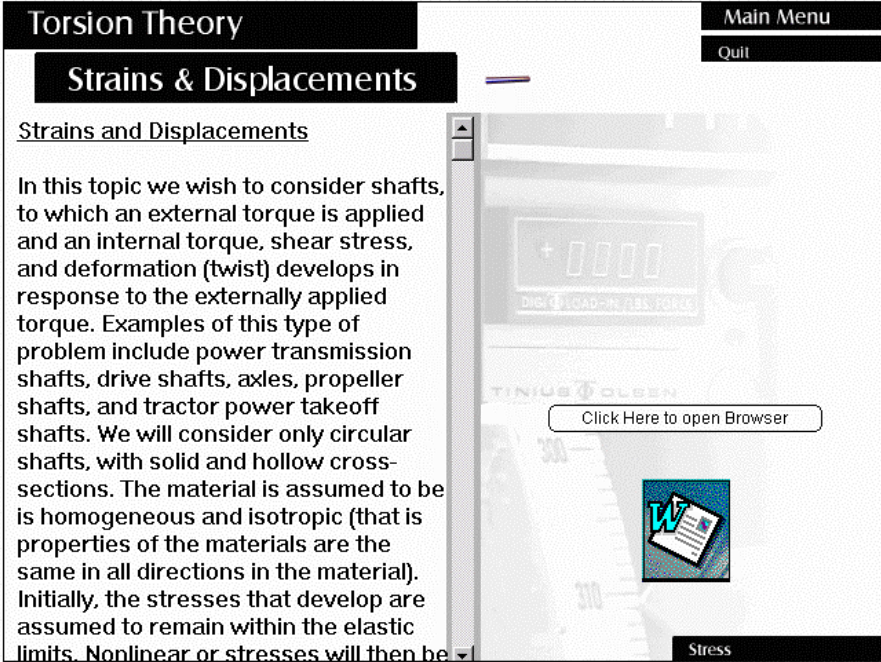


Figure 4. Multiple Ways of Viewing Material

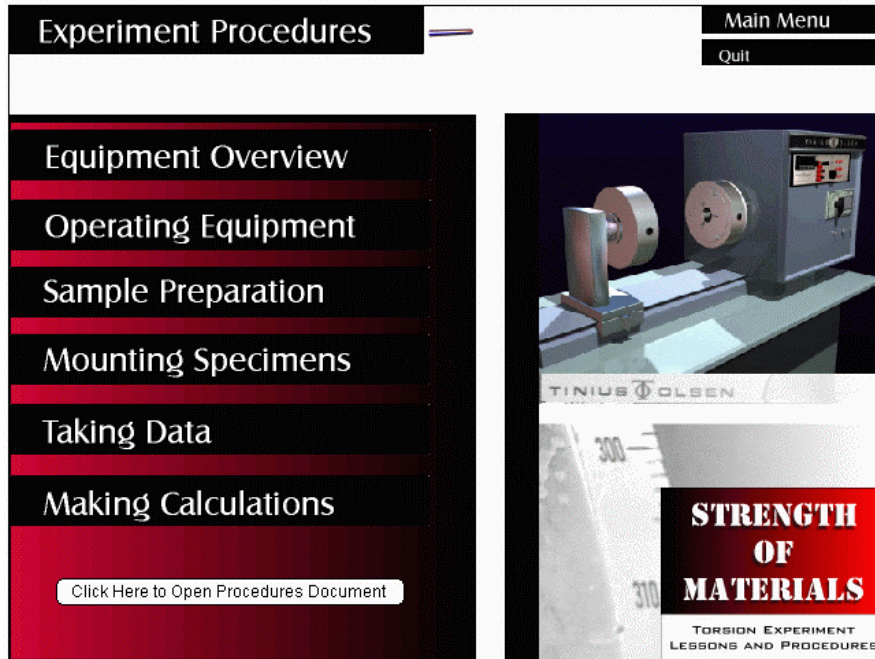


Figure 5. Experimental Procedures Menu Screen



Figure 6. Video-Clip Showing How to Operate the Equipment

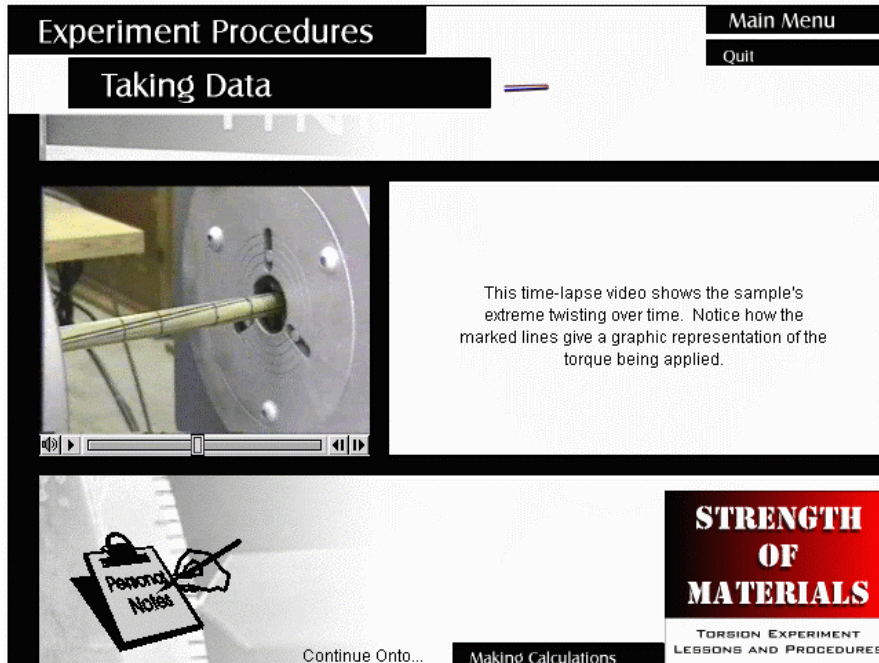


Figure 7. Video-Clip of Experiment in Progress

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