AC 2008-928: INTERACTIVE TUTORIAL MODULES FOR BASIC MECHANICS TOPICS

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Interactive Tutorial Modules for Basic Mechanics Topics

Abstract

This paper describes the different modules that have been created for several key mechanics topics, using *Respondus* in conjunction with WebCT Vista. . Each module supplies a diagnostic correction mechanism that identifies common student errors and provide specific feedback based on the type of mistake encountered. The examples in each module attempt to improve comprehension of a concept by leading students through a series of questions demonstrating how complex solutions are created by integrating individual small steps. In examples at the beginning, students are asked very basic questions about the material. Students then fill in blanks on the web page, select from multiple answers, or seek more in-depth help on the matter. When students answer a question, they are given instant feedback. Wrong answers lead to feedback on how the correct solution can be reached while correct answers allow students to move on to the next series of questions. The degree of difficulty increases with subsequent examples and asks students to do more steps simultaneously in order to fill in more than one blank or make more than one choice. The organization forces students to actively process the information in the example instead of just skipping ahead regardless of their consequences.

The paper also explains the development process for the modules, the student usage expectations and plans for future evaluation of any positive results.

Introduction

A lack of understanding of the basic principles of Mechanics of deformable bodies is frequently observed among several Engineering Technology majors. These include concepts of free-body diagrams, stress, deformation, and shear and moment diagrams under different loadings. Since these constitute the foundation for the upper-level courses such as Structural Analysis and Structural design (Steel/ Reinforced Concrete), it is essential for the students to have a sound comprehension of all these concepts so they can apply them properly.

These students are juniors or seniors, and have already taken at least two courses in Mechanics: Statics and Strength of Materials. While dedicating class time to revisit those basic concepts can be of some assistance, the ability to practice in a positive environment that provides immediate feedback could be significantly more enlightening. Furthermore, the constraint of time to cover the course material for the upper level course always precludes any elaborate in-class reviews of background materials. However, online tutorials provide an out-of-class mechanism for students to learn key concepts, and well-crafted tutorials will help students to learn from the mistakes they make.

There are several computer-aided tools[1,2,3,4,5] available to help students formulate the problems, solve them, and even test their understanding of subject matter[6]. Most of these tools are accompanied by graphics to present the problem and its solution. These applications can be classified into two categories: (a) commercially available software and (b) application programs developed in-house. While the commercially available software are versatile in solving a variety of problems, they are expensive and usually have a learning curve associated with them. On the contrary, tools developed in-house are simpler in nature, less expensive to develop, and the students can learn the system faster. In this paper, a computer-aided tool developed by the author is presented, the objective being to help students identify their strengths and weaknesses in comprehending the basic concepts of mechanics and rectify their mistakes through online tutorials out of the classroom.

A significant number of modules have been created for several key mechanics topics, and several more are under preparation. Each module supplies a diagnostic correction mechanism that identifies common student errors and provide specific feedback based on the type of mistake encountered. The development process and details of the modules are discussed next.

Modules Development Process

The topics covered with the modules are as listed below.

º Free-body diagrams
º Internal reactions
º Shear and moment diagrams under different transverse ladings
º Concept of stress under different loadings:
- Normal stress under axial loading
- Normal stress under transverse loading
- Normal stress under combined loading
- Shear stress under transverse loading
- Shear stress under torsional loading
- Shear stress under combined loading

º Concept of strain and deformation:
- Deformation under axial loading
- Deformation under transverse loading
- Deformation under torsional loading

º Concept of principal stresses (use of Mohr's circle)
- Plane stress

º Column buckling

Each topic is covered with one module, and each module contains several exercises. The software used to develop these modules is called *Respondus*. It is a Windows-based authoring tool that makes it easy to create and manage exams for Blackboard, WebCT, ANGEL, eCollege and other learning systems. *Respondus* is a powerful application for creating and managing exams that can be printed to paper or published directly to WebCT Vista used at this institution.

Each module supplies a diagnostic correction mechanism that identifies common student errors and provide specific feedback based on the type of mistake encountered. The examples in each module attempt to improve comprehension of a concept by leading students through a series of questions demonstrating how complex solutions are created by integrating individual small steps. In examples at the beginning, students are asked very basic questions about the material. Students then fill in blanks on the web page, select from multiple answers, or seek more in-depth help on the matter. When students answer a question, they are given instant feedback. Wrong answers lead to feedback on how the correct solution can be reached while correct answers allow students to move on to the next series of questions. The degree of difficulty increases with subsequent examples and asks students to do more steps simultaneously in order to fill in more than one blank or make more than one choice. The organization forces students to actively process the information in the example instead of just skipping ahead regardless of their consequences

In developing each module, first multiple scenarios are considered; and then for each of these possible situations as many exercises are prepared as warranted by the topic addressed. Three examples are presented in this paper (see Appendix). Two exercises are presented in Example 1 pertaining to the topic of internal reactions at two different locations of a beam shown in Figure 1. The feedback information is also included in each exercise. The reason for providing these two exercises on the same topic is for the students to recognize that there is a fundamental difference in terms internal forces between these two locations, which in turn would translate to different stress conditions at these two sections (1-1 and 2-2). Example 2 is on calculation of stresses using the same beam in Example 1. Two exercises are shown – one for normal stress at point A at section 1-1 due to combined loading and the other for shear stress at point B at section 2-2. Example 3 is on the topic of deformation due to axial loading. Here also, the module includes several exercises to show different amounts of deformation that will occur at different points; only one case, however, is shown as an example.

The author plans to develop a total of about 90 exercises covering the above topics. Thus far 35 such exercises have been completed; the remainder is expected to be done within six months.. Each exercise takes anywhere from 60 to 90 minutes from formulating the problem to actually publishing it online. The only investment in this project is the faculty time, as there is no other cost involved. The author plans to publish an updated paper (including assessment results) within two years upon completion of development of all the modules.

Student Usage

It is the intent of the author to incorporate this teaching tool in the junior-level Structural Analysis class starting fall 2008 semester (Strength of Materials is one of the prerequisites for this course). Students will have online access to these modules, and will use them as necessary (It is not expected that every student will need to use every single module).

Plans for Evaluation

The author plans to review the key concepts of mechanics that are essential for the upper-division course at the beginning of the semester in two class periods followed by a quiz covering several topics during the third class period. The quiz scores will be considered as Pre-test scores. Then the developed tutorial modules will be released for student access. They will have two weeks to use them before they take another quiz, and those scores will be considered as Post-test scores. A comparison of the two sets of scores will testify to the efficacy of the tool. A weighted average of the Pre-test and Post-test scores will account for 8-10% of the course grade. The modules will remain available to the students throughout the semester for them to use, if need be.

Summary

Interactive tutorial modules have been created to facilitate student learning outside of classroom at their own pace and time. The modules have been created primarily to alleviate the situation of students' lack of understanding of basic mechanics topics (covered in a prerequisite course) that are essential for the higher-level courses. *Respondus,* a Windows-based powerful authoring tool that makes it easy to create and manage exams for WebCT Vista has been used to create the modules. It is planned to use the tool in fall 2008, and report the results of its usage subsequently by which time further enhancement of the tool is likely.

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Appendix

<u>Example 1</u>

A cantilever beam has a rectangular cross-section (2 in. x 8 in.) and is acted upon by two loads in the plane of symmetry as shown in Figure 1.

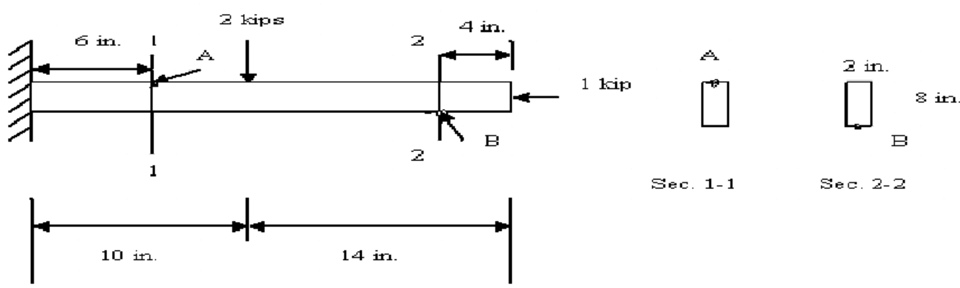

Figure 1

Identify the internal reactions at section 1-1.

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- a. Axial force only.
- b. Axial force and shear force.
- c. Axial force, shear force, and bending moment.

Feedback

0.0% a. No. Because there is a transverse load acting as well.

0.0% b. No. Because the transverse load will cause bending as well.

100.0% c. Yes. That is correct.

Identify the internal reactions at section 2-2.

- a. Axial force only.
- b. Axial force and shear force.
- c. Axial force, shear force, and bending moment.

Feedback

100.0% a. Yes. That is correct.

0.0% b. No. Because the transverse load will not have any effect at section 2-2.

0.0% c. No. Because the transverse load will not have any effect at section 2-2.

Example 2
A cantilever beam has a rectangular cross-section (2 in. x 8 in.) and is acted upon by two loads in the plane of symmetry as shown in Figure 1.

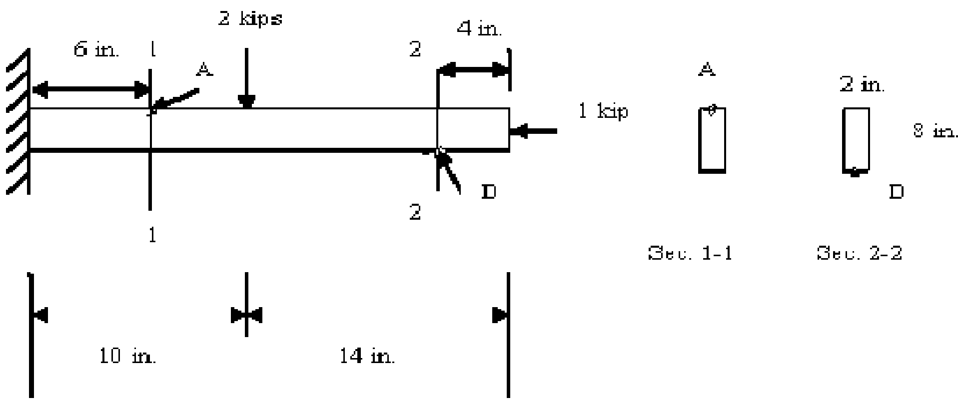

Figure 1

The normal stress at point A is most nearly

- a. 0
- b. 63 psi (compressive)
- c. 375 psi (compressive)
- d. 437 psi (compressive)

Feedback

0.0% a. No. Because an axial force and a bending moment of non-zero magnitudes act at section 1-1.

0.0% b. No. Because this does not include the normal stress due to moment.

0.0% c. No. Because this does not include the normal stress due to the axial load.

100.0% d. Yes. That is correct.

The shear stress at point A is most nearly

- a. 0
- b. 125 psi
- c. 187 psi

Feedback

100.0% a. Yes. That is correct.

0.0% b. No. Because point A is located on the beam surface (i.e., at an extreme fiber farthest from the neutral axis).

0.0% c. No. Because point A is located on the beam surface (i.e., at an extreme fiber farthest from the neutral axis). .

<u>Example 3</u>

A cantilever beam ABC made of an Aluminum alloy has a rectangular cross-section (0.5 in. x 6 in.) and is acted upon by two axial loads at B and C, as shown in Figure 2. The Modulus of Elasticity of the Aluminum alloy is 10,000 ksi.

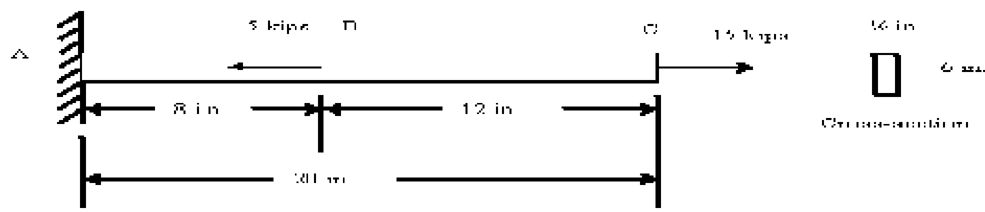

Figure 2

The elongation of the bar due to the applied loads is equal to

- a. 0.0027 in.
- b. 0.006 in.
- c. 0.0087 in.
- d. 0.01 in.

Feedback

0.0% a. No. To determine deformation, you need to consider the beam to be composed of two simple segments, each having a different internal reaction (axial force).

0.0% b. No. To determine deformation, you need to consider the beam to be composed of two simple segments, each having a different internal reaction (axial force).

100.0% c. Correct answer.

0.0% d. No. To determine deformation, you need to consider the beam to be composed of two simple segments, each having a different internal reaction (axial force)