Session: 2793

A ONE CREDIT HOUR WEB-BASED STATICS COURSE

Muniram Budhu

Department of Civil Engineering & Engineering Mechanics.
University of Arizona, Tucson, AZ 85721

Abstract

In this paper, a web-based one-credit hour course in Statics is described. The intention of the course is to help solve the problem of a shrinking engineering curriculum yet providing a rich course content for the student to get the desired knowledge. The goal is to use visual media materials that include interactive animation to enhance retention of fundamental concepts in Statics and their use in problem solving. The development and arrangement of topics to provide opportunities for students to learn course materials to be successful in the Fundamentals of Engineering (FE) examination are described. Students follow a flow chart that consists of review materials in geometry, algebra, trigonometry, vectors, calculus and physics, a pretest, and various components of the Statics course material culminating in an FE type examination. The bulk of the course material consists of interactive animations of the various concepts in Statics. The course material is divided into components and the students must pass each component before taking the FE type examination.

Introduction

There is a growing demand on engineering departments to streamline their undergraduate curriculum to reduce credit hours and to include more technical content, personal development and communication skills. In addition several institutions, including the University of Arizona, have new requirements for freshmen. All freshmen must now take a university wide core curriculum in their freshman and sophomore years that include courses not normally included in an engineering curriculum. The consequence is that a number of institutions are now faced with the challenging task of reengineering their undergraduate curriculum. What courses to cut? How should we manipulate the content of a course or courses to increase efficiency and reduce credit hours? What is the likely impact of course cutting measures on professional engineering examinations and performance of students in the work place? These are some of the questions that engineering departments have to answer in conducting renewal of their curriculum.

One of the possible casualties of course cutting and credit hour reduction is engineering mechanics (Statics). Some engineering departments, for example, Electrical Engineering and Systems and Industrial Engineering at the University of Arizona, have dropped Statics as a course requirement for their students. However, if these engineering students want to become registered engineers, they must pass the Fundamental of Engineering (FE) examination, which has a required Statics component. These students must then learn Statics through self-study or take a course at a community college after graduation.

An alternative to the non-requirement of Statics for an undergraduate degree is to reduce the number of credit hours, usually from 3 to about 1 or 2 credit hour. But, how to achieve this reduction? This must be accompanied by a reduction in course content. However, the FE examination does require knowledge that would normally be obtained from a 3 credit hour course content. This poses a dilemma. In this paper, a possible solution to this dilemma is proposed.

Webs-based Statics course

An examination of the FE examination in Statics will show that the topics covered do require a conventional three-credit hour of course work. The topic lists, following the order in the table of contents of popular textbooks, are: forces, moment, equivalent systems, equilibrium of rigid bodies, trusses, frames, shear force and bending moment, friction, centroids and second moment of area. There are two key difficulties in attempting to structure a one-credit hour course to meet the requirements of the FE examination. One is the organization of the course content to cover the breadth and depth of the various topics. The other is the delivery of the course. One solution to the latter difficulty is to deliver the course in a Web-based format with provision for faculty-student interaction. The Web-based format allows a student to take the course at any time and any place. A few institutions (for example Oklahoma University, Zaman and Kukketi, 1998) already have some Statics course content on the Web. The former difficulty is considerable. A possible solution is shown in the flow chart in Figure 1.

The course arrangement in Figure 1 allows for

- The testing of pre-requisite knowledge or readiness assessment
- An efficient course structure
- Evaluate retention
- Evaluate performance

The course arrangement consists of four groups of modules. Each group is a milestone that a student must pass before proceeding to another group. The four groups are:

(1) Readiness Assessment
(2) Individual topics - forces, moment, etc., required for the use of the equilibrium equations.
(3) Equilibrium equations and applications
(4) Fundamentals of Engineering type examination

Within a group a student can explore any its modules. Each module consists of instructional material on the basic concepts, applications, examples, and evaluation. The flow chart shown in Figure 1 illustrates how the module is put together.

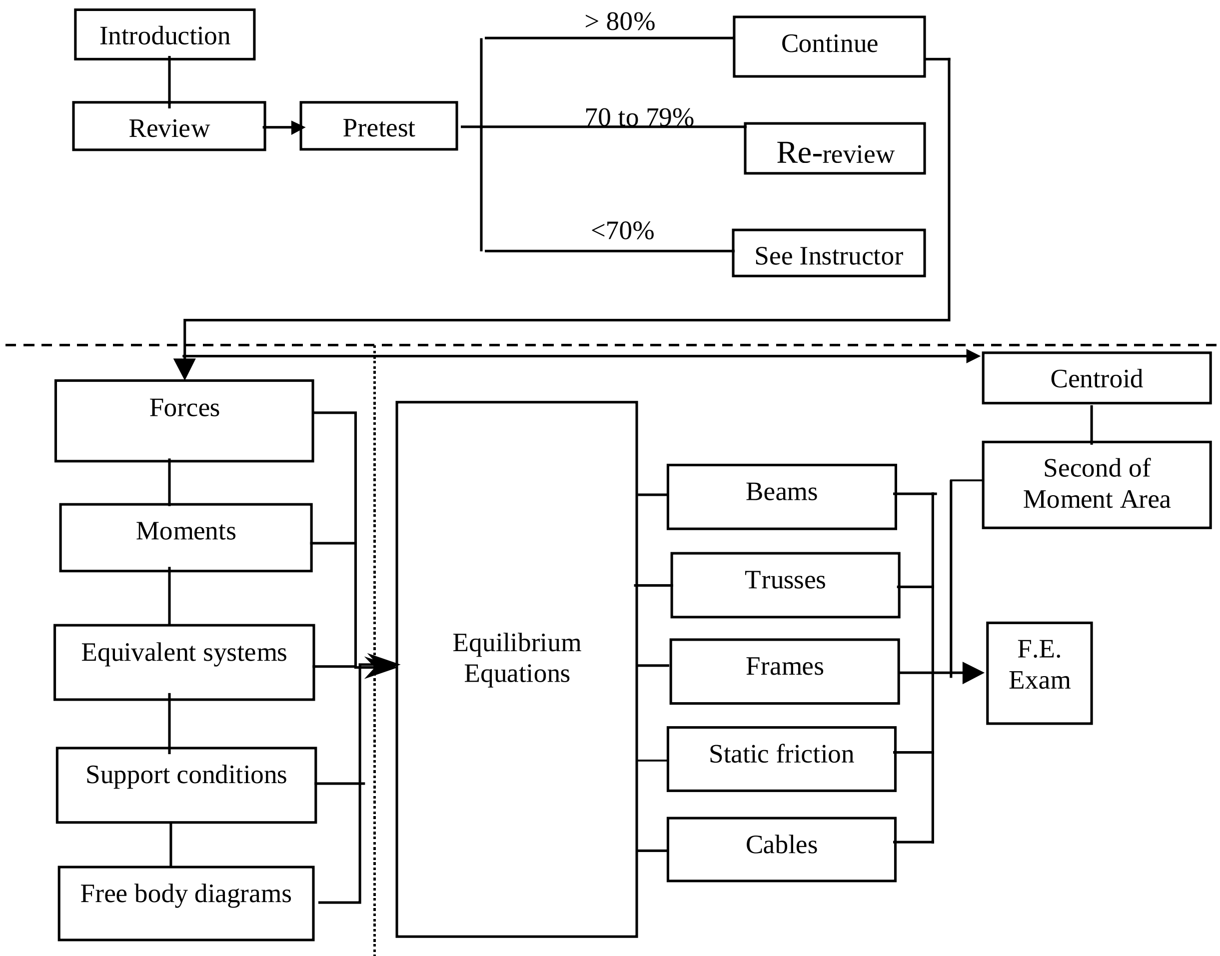

Figure 1 Course arrangement

Readiness Assessment

In many institutions, Statics is the first "real" engineering course that a student takes. Often, students entering the course are either not well prepared in the fundamentals such as physics and mathematics or have forgotten them. To prepare students for the course, review materials of the relevant principles in algebra, geometry, trigonometry, vectors, physics and calculus are available for a student to peruse. Interactivity and animation are used wherever they can enhance learning and retention. A student must pass a web-based examination on the pre-requisite knowledge before proceeding to the course material. The examination can be taken any time a student wishes to do so. If a student passes the examination, a password is issued to allow him/her access to the next course level. If a student scores between 70 and 79%, he or she can retake the examination. If a student scores below 70% he/she must see the instructor for advice. Each student has the same type of questions but with given parameters that are randomly generated. A student retaking the examination has a different set of examination questions.

Course Material

The essence of Statics is the application of Newton's second law when the acceleration on a rigid body is zero. The core of an undergraduate course in Statics is then an understanding of the equilibrium equations and their use in problem solving. But before a student can understand the equilibrium equations, he/she must understand the concepts of forces, moments, equivalent systems, support conditions, and free body diagrams. Therefore, before a student proceeds to equilibrium equations he/she must demonstrate mastery of forces, moments, equivalent systems support conditions, and free body diagrams. The course materials for each of these are presented using text-based material and interactive animations to cater for the verbal, visual, active and passive learners as deferred by Felder and Silverman (1988). An example of three frames of an interactive animation of finding the components of a force in two dimensions is shown in Figure 2.

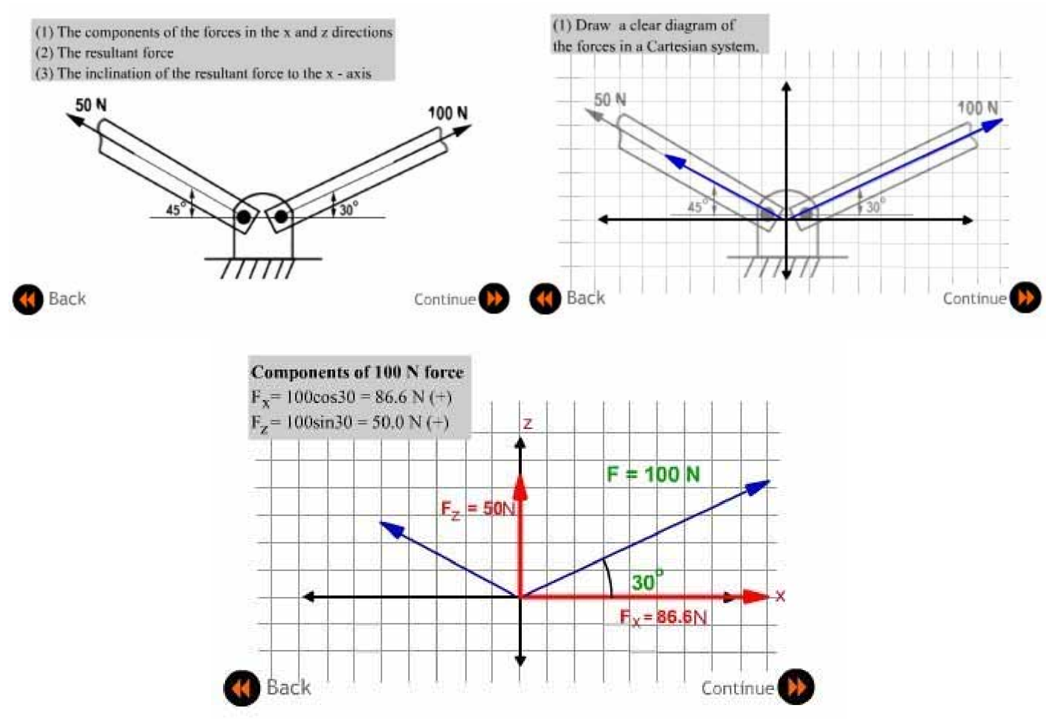

Figure 2 Three frames of the interactive animation for determining components of forces

A student must pass a multiple choice web-based test on each of forces, moments, equivalent systems and free body diagrams before a new password is issued to proceed to equilibrium equations.

In the equilibrium equations and applications group, the student is instructed on the equilibrium equations and their use in problem solving. The student can then proceed to instructions in any of the following modules: beams, trusses, static friction, frames and cables. Interactive animation is used to illustrate key concepts. Two frames in the frame module are shown in Figure 3.

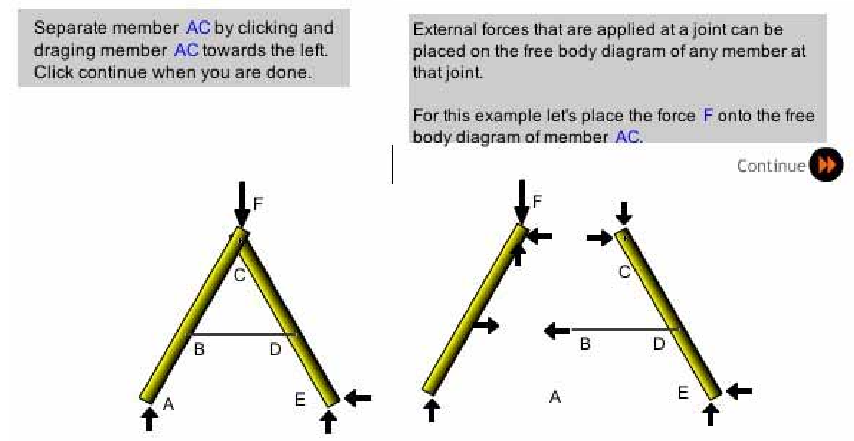

Figure 3 Two frames from the interactive animation of the frames module

After passing examinations in each of these modules, the student can then proceed to take a PE type examination.

Centroids and second moment of area do not fit into the realm of instructional materials needed for the use of the equilibrium equations. Centroids are required to determine the center of mass, area, and volume of an object and require knowledge of geometry and calculus. Second moment of area is a geometric property that is used in determining bending stress and stiffness. Thus, the determination of centroids and second moment of area is best introduced to the students at the beginning of the course when they are most likely to remember the appropriate mathematics principles. Following the use of the equilibrium equations, a student is issued with a new password to enable him/her to take a PE type examination. All examinations are graded by the computer and a record is kept of each student's performance on each question. Improvement to the instructional material is based on the evaluation of students' performances and web-based questionnaires.

Assessment

The one-hour web-based Statics course is now under trial at the University of Arizona. For fall'99, students are taking the regular three-credit hour course and using the web-based course as a supplement. Formal testing using two batches of students – one batch taking the regular three-credit hour and another batch taking the one-credit hour course – will begin in Fall'2000.

References

1. Felder, Richard.M. and Silverman, Linda. K. Learning and Teaching Styles in Engineering Education, Engineering Education, ASEE, 1988, pp. 674-681
2. Zaman, M. and Kukketi, A Impact of Computer-based Learning Tools in Rigid Body Mechanics, 33rd ASEE Midwest Section Conference, Kansas State University, Salina, Kansas, April 9-10, 1998.

Acknowledgement

The work described in this paper was supported by a grant from General Electric Corporation to the University of Arizona.

Muniram Budhu is a Professor of Civil Engineering & Engineering Mechanics at the University of Arizona. He teaches courses in Statics, Soil Mechanics and Foundations Engineering. He is involved in developing multimedia

courses and has recently published a textbook on Soil Mechanics and Foundations that is accompanied by a CD-ROM that contains interactive animations of the basics topics, interactive problem solving, virtual laboratories, quizzes, etc. Professor Budhu received his BSc degree in Civil Engineering from the University of the West Indies and his Ph.D from Cambridge University.