# Learning Basic Mechanics with Multimedia

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## Abstract

We have developed a workshop style learning environment that combines topics of statics and mechanics of materials. It includes physical models, interactive multimedia, traditional pencil-and-paper activities, and cooperative learning in the framework of experiential learning (Kolb, 1984). A section of statics-mechanics of materials in this format was taught for the third time in the spring 1999 to students in architecture. Student feedback provides the information to improve the learning environment and to develop more effective multimedia learning modules.

## Introduction

> *…for the computer to bring about a revolution in higher education, its introduction must be accompanied by improvements in our understanding of learning and teaching...* Nobel Laureate Herbert Simon [Kozma and Johnston, 1991]

Simon's statement has been a guiding theme in the development of a multimedia learning environment that combines topics of statics and mechanics of materials. The course has evolved into a workshop style environment [Laws, 1991] that includes physical models, interactive multimedia, traditional pencil-and-paper activities, and cooperative learning in the framework of experiential learning (Kolb, 1984). Authorware Professional is used to construct the multimedia program. A section of statics-mechanics of materials in this format is taught for the third time in the spring of 1999 to students in architecture.

In this paper we briefly describe the learning environment (Holzer and Andruet, 1998) and how students are guided to develop the concepts of moment, bending moment, and the condition of moment equilibrium.

## Learning Environment

> *Learning is the process whereby knowledge is created through the transformation of experience.* **David Kolb** (1984)

**Experiential Learning.** Experiential learning focuses on the two fundamental activities of learning: grasping and transforming experience (Fig. 1). Each activity involves two opposite but complementary modes of learning. One can grasp an experience directly through the senses (sensory, inductive mode) or indirectly in symbolic form (conceptual, deductive mode). Similarly, there are two distinct ways to transform experience, by reflection or action. At any moment in the learning process, one or a combination of the four fundamental learning modes may be involved. It is significant that their synthesis leads to higher levels of learning (Kolb, 1984). This is confirmed in a study by Stice (1987), which shows that the students' retention of knowledge increases from 20% when only abstract conceptualization is involved to 90% when students are engaged in all four stages of learning.

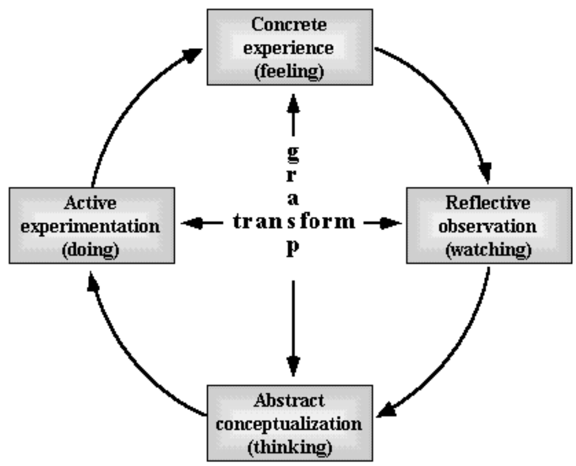


Figure 1. Experiential Learning Model (Kolb, 1984, p. 42)

**Cooperative Learning.** Cooperative Learning is a structured learning strategy in which small groups of students work toward a common goal (Cooper, et al., 1994). It enables us to transform the experiential learning model into and active learning environment. The course is taught in a computer lab, where two students share one computer. This facilitates pair activities, which include think-pair-share (**TPS**) (Lyman, 1987) and think-aloud-pair-problem-solving (**TAPPS**) (Lochhead, 1987). In **TPS**, students think about a problem individually to organize their thoughts, they form pairs to share and discuss their solutions, and they share and discuss their findings with another pair or a larger group. In **TAPPS**, each pair is divided into a think-aloud problem solver and a listener, each with specific instructions. Their roles are reversed after every problem, but not during a problem.

**A Session.** A session generally consists of three parts: (1) a warm-up problem, short group activities that focus on problems or questions that surfaced in homework, weekly quizzes, or minute papers (Cross, 1991); (2) mini lectures (10-15 minutes long) interspersed with cooperative activities; (3) and a minute paper, where students are asked to reflect and answer questions about the day's lesson and activities. The multimedia program provides the learning content and activities to engage students through fundamental learning modes (Kolb, 1984).

The challenge is to achieve a good balance among the various activities. The following guidelines facilitate learning: (1) Give students the opportunity to master one topic before moving to the next (Terenzini and Pascarella, 1994); (2) frequently place topics in context of the course framework and objectives, the students' background, and real engineering problems; and (3) provide and receive frequent feedback. It is also important to communicate high expectations, the students' responsibility for learning, and the benefits of helping one another learn (AAHE, 1996).

## Moments and Equilibrium

We are building on the students' intuitive notions of balance, acquired through their childhood experiences with seesaws, to help them develop the concept of moment and the condition of moment equilibrium. The experiential learning model (Fig. 1) is reduced to three steps in this development (Fig. 2): concrete experience and reflective observation are combined in **turning effect**; abstract conceptualization is conducted in **equilibrium** and active experimentation in **testing;** only turning effect and equilibrium are addressed here.

**Turning effect**. The students work in teams through a series of questions using **TPS**, **TAPPS,** or variations of these structures. The key question about the cause of the clockwise rotation leads to a measure of the turning effect, which is defined as moment (Fig. 3). Defining concepts after some exploration facilitates learning ( Arons, 1990, p. 111): “idea first and name afterwards.”

**Equilibrium**. The balance condition is generalized to the condition $\Sigma M_0 = 0$ and a moment sign convention is introduced (Fig. 4). Next, the students are guided to discover that the net moment about any point in the plane is zero; they are asked to state the conditions of equilibrium of a body in a plane. The answer (Fig. 5) reveals Euler’s extension of Newton’s conditions of equilibrium to finite bodies.

### Bending Moment

The experiential learning model is again used to learn about internal forces in beams (Fig. 6): the inductive approach guides the development of concepts and procedures, and the deductive approach, starting with a summary of findings, guides the analysis of problems. Some steps in the development of the concept of bending moment are illustrated. An effective way to reach learners is to use “first induction, then deduction” (Felder and Silverman, 1988).

After exploring bending deformation and the resulting compression and tension faces of beams, students are asked to graph the normal stress, representing experimental data, over the cross section of a beam (Manual in Fig. 7). Two- and three-dimensional graphs (Fig. 8) are provided for comparison. The final task is to compute the couple corresponding to the stress blocks. Figure 9 illustrates one step in this process; the second incorrect value for the compressive force, F, results in the Note in Fig. 9. Generally, the program responds with a clue to the first error and the solution to the second error.

## Student Evaluations

Although occasionally a student doesn’t like the computer as a learning tool, on the whole the students are actively engaged in learning, and teaching is rewarding. The following excerpts from student evaluations provide some insight into their learning experiences:

- *I never realized how much I can learn by helping others.*
- *Yes, the* [multimedia program] *did facilitate learning by providing an interactive learning procedure where principles were developed and expanded upon active involvement with concrete and abstract example problems.*
- *Yes* [the multimedia program] *helped me a lot. It was really good to see examples and how they worked.*

- *Yes* [the multimedia program facilitated learning]. *It worked very well in class time and with a partner.*
- *I used it [the multimedia program] a lot out of class and found it very helpful.*
- *His system with the computer, "think-pair-share" learning teams, and in-class problem solving is the most effective way to learn such subject matter that I have encountered in 16 years of schooling.*

## Acknowledgment

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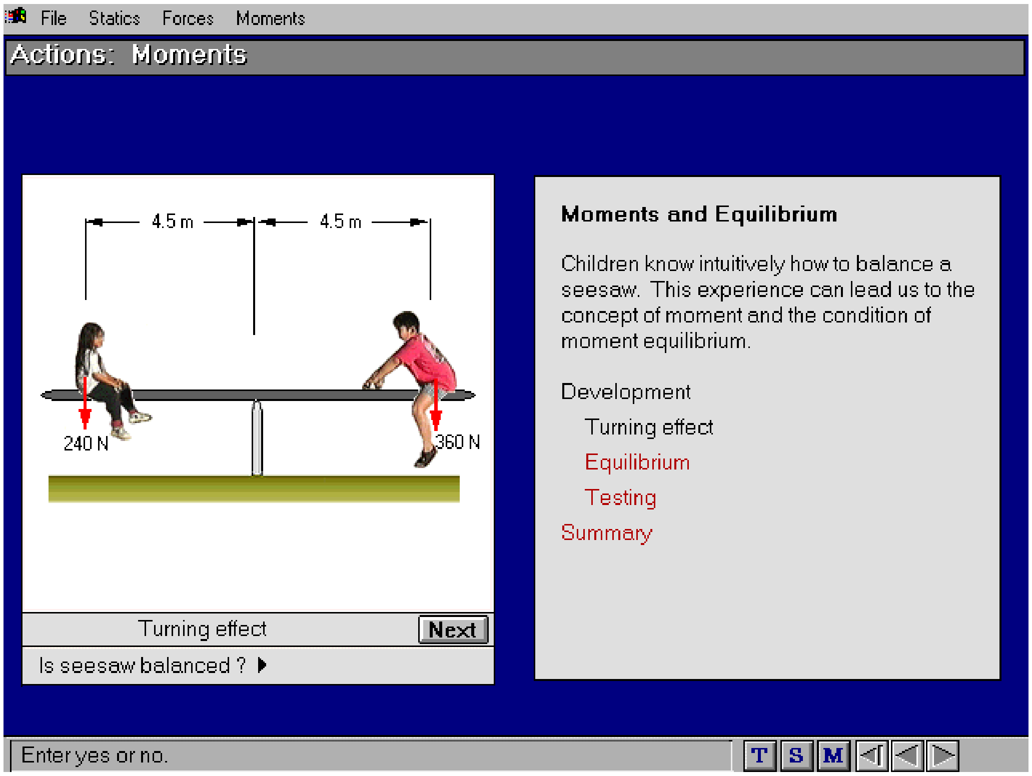


Figure 2. Moments and Equilibrium

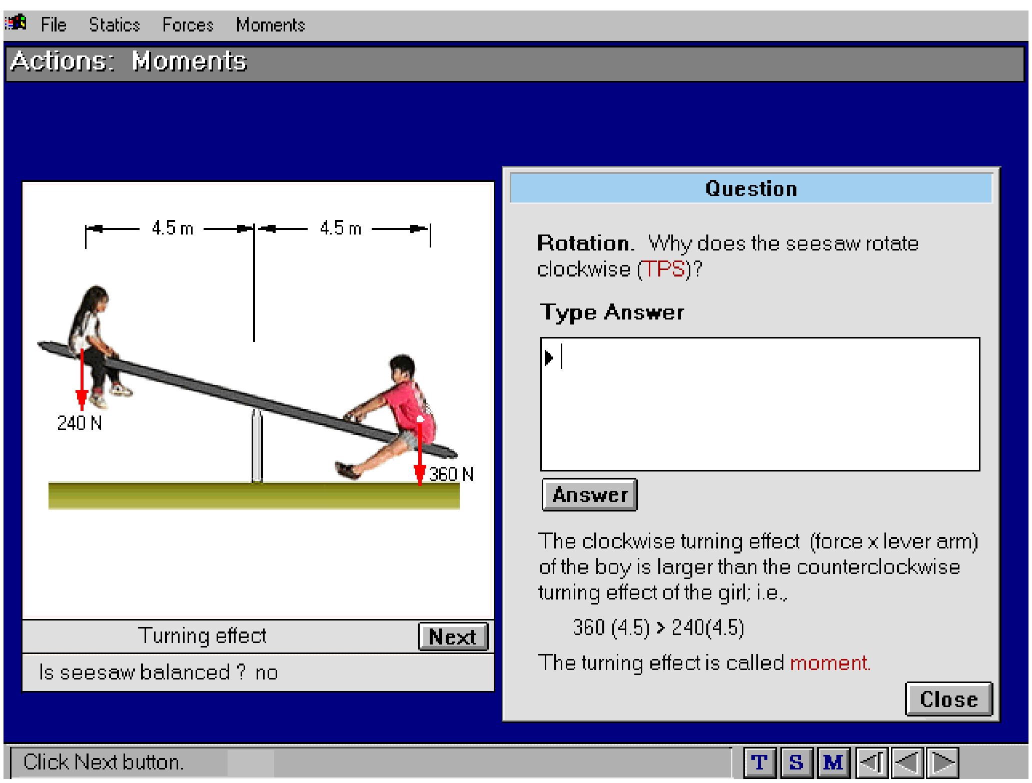


Figure 3. Turning Effect

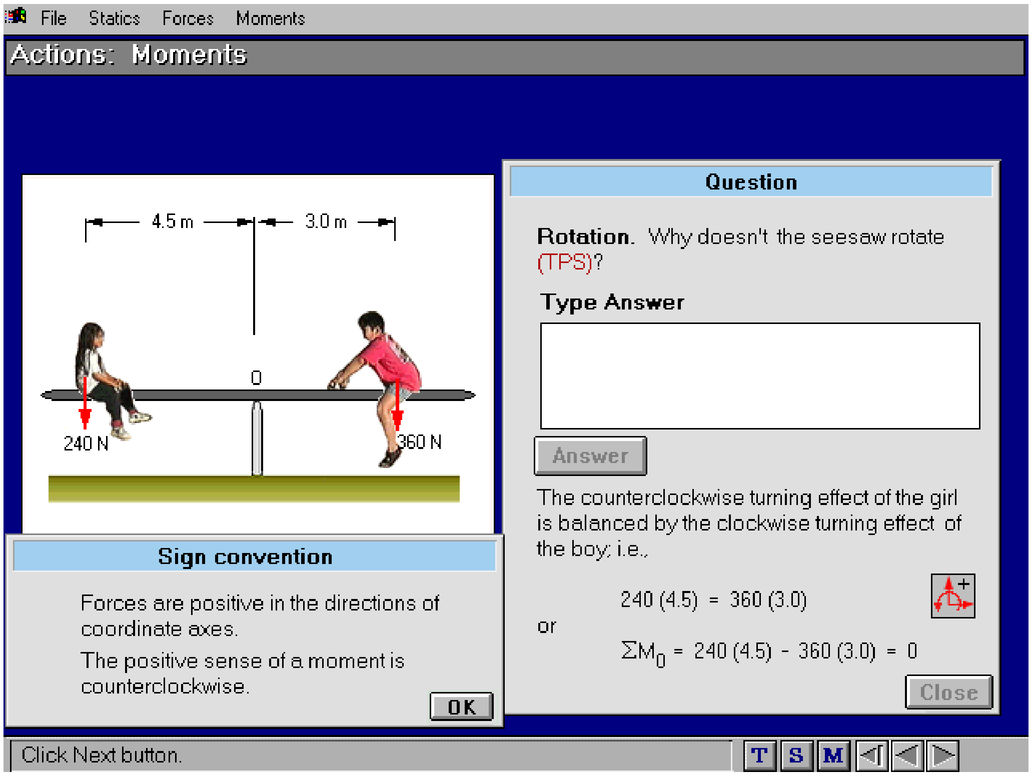


Figure 4. Balance Condition

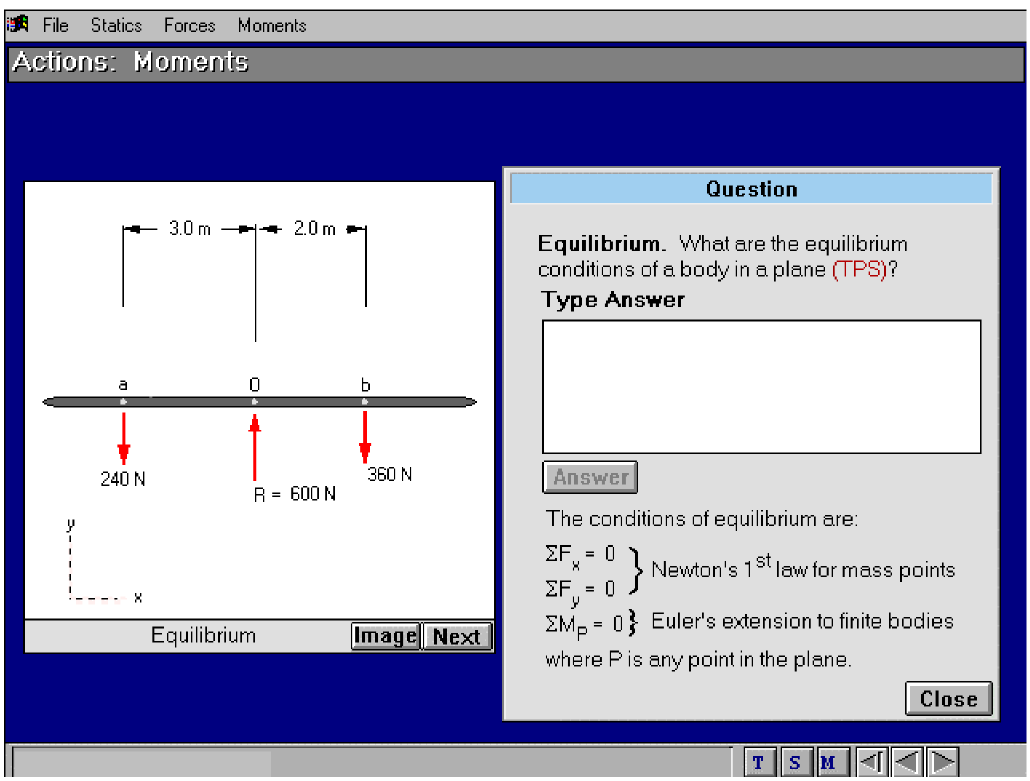


Figure 5. Conditions of Equilibrium

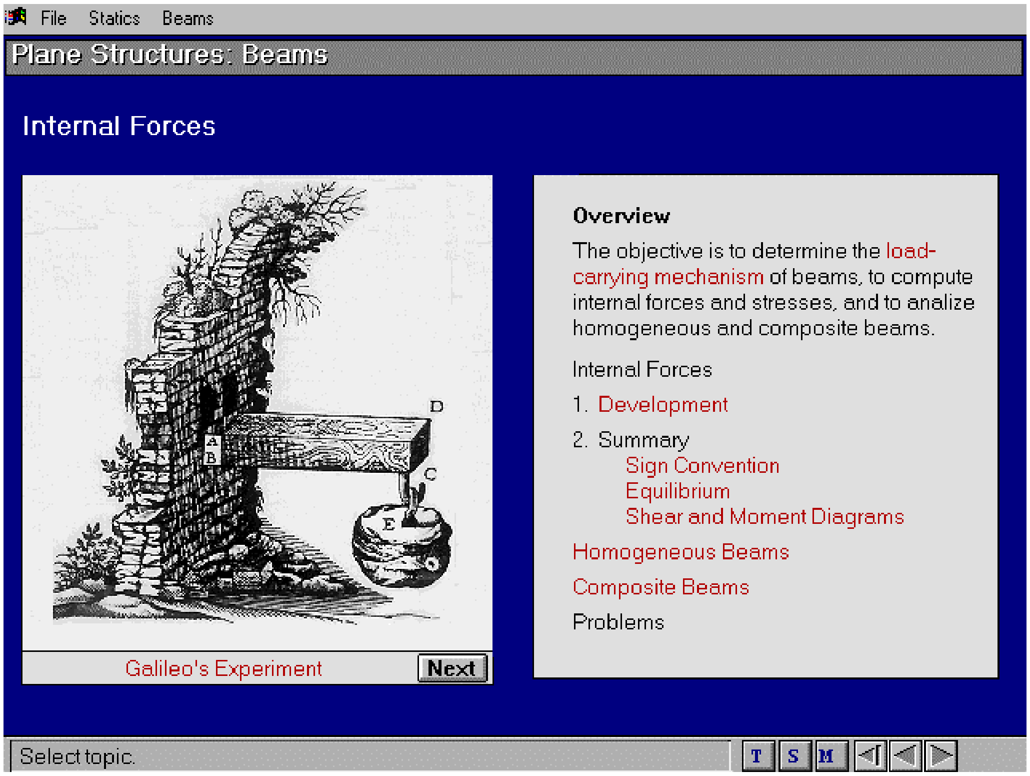


Figure 6. Internal Forces

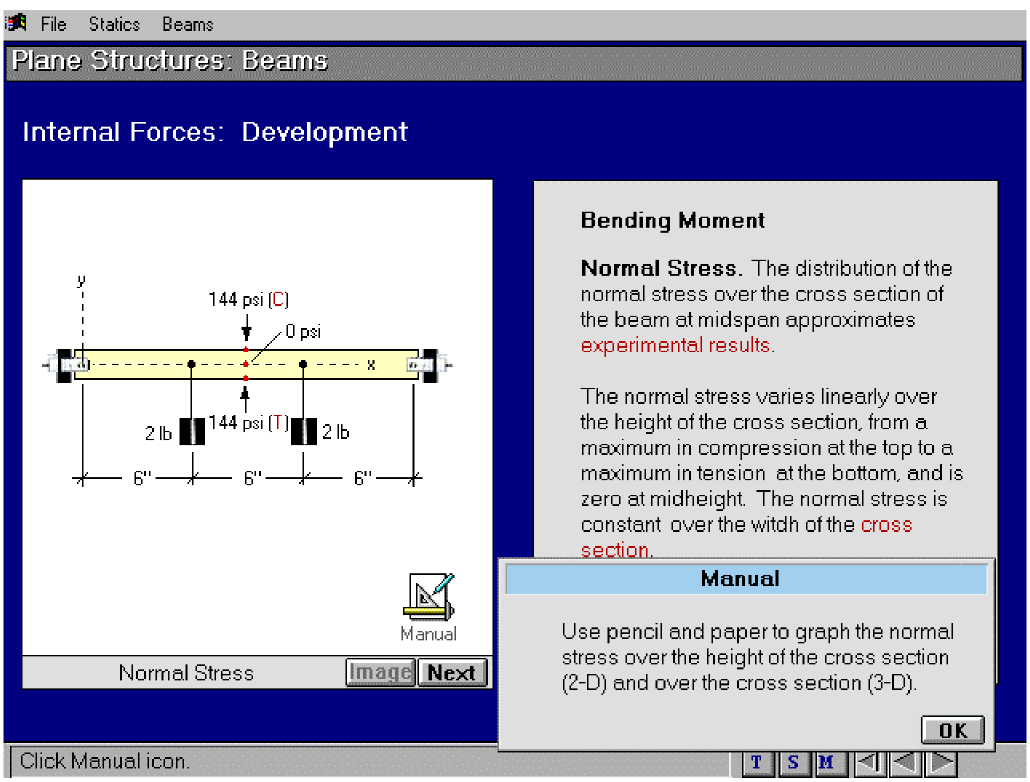


Figure 7. Normal Stress

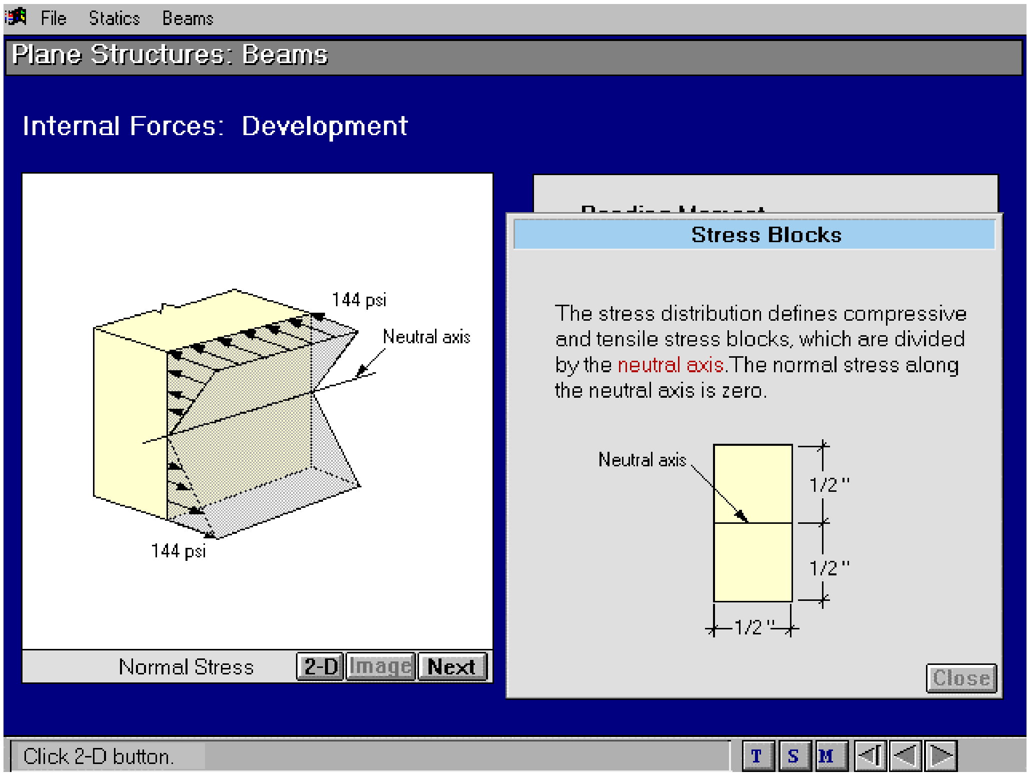


Figure 8. Stress Distribution

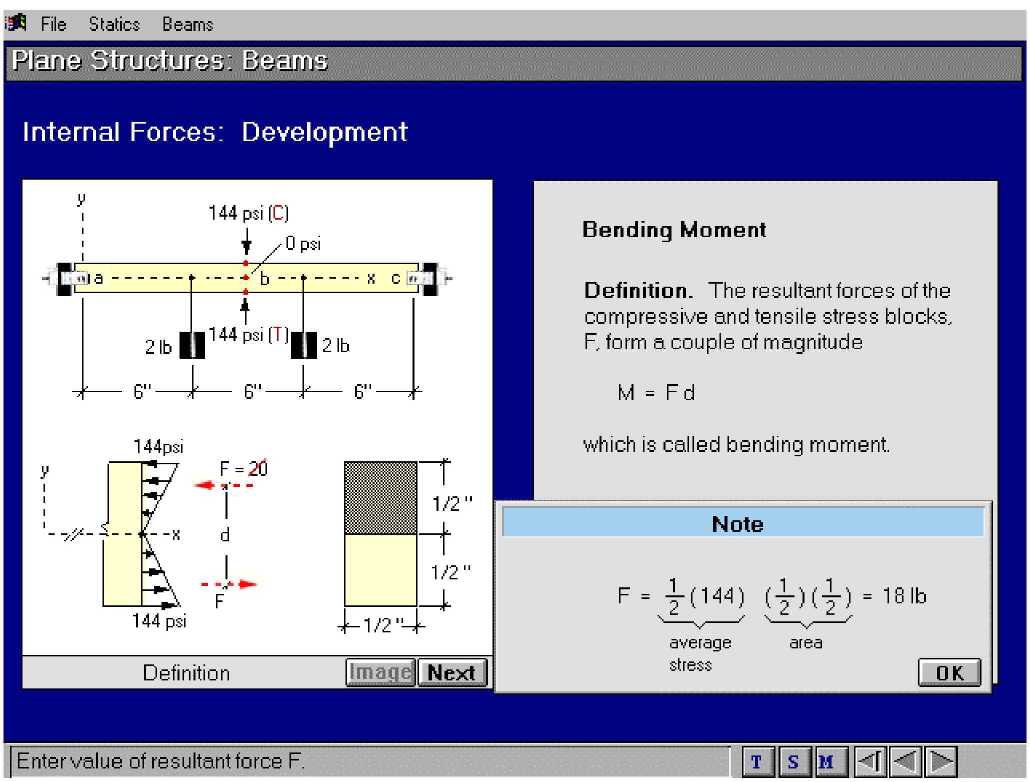


Figure 9. Bending Moment