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N90-24688

A NASTRAN TRAINER FOR DYNAMICS

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OVERVIEW

As the use of the finite element method proliferates, the need for training becomes more and more pronounced. An automated tool to familiarize engineers with static solutions has been developed and used. This tool (Figure 1) is part of an overall structural analysis/expert training system (ref. 1). Experiences with this tool and comments from users (ref. 2) have underlined the need for a dynamic version of the trainer.

This paper presents an automated training tool that engineers can use to master the application of NASTRAN to dynamic problems. The paper consists of the following sections:

- Overview
- Background
- Existing Programs
- Scope, Purpose, and System Organization
- Example Problems
- Conclusions
- References

Example problems have been selected to make classical solutions available for comparison. These comparisons can be used to evaluate the solution.

BACKGROUND

The solution of dynamic problems involves some complications that do not exist with static problems:

- How many degrees of freedom should be retained for the eigenvalue solution?
- Which discrete mass items are so large or important that they should be retained for eigenvalue solution?
- How many frequencies and mode shapes are needed and to what accuracy?

An engineer may think that most of the mass associated with a structure can be traced to the structural members themselves; this is not necessarily true. With many aircraft and spacecraft, the nonstructural masses (e.g., hydraulic lines, fuel tanks, environmental control equipment, etc.) have a pronounced influence on the overall mass distribution and may have the greatest dynamic effect.

The example problems have distributed masses and lumped masses that the user must consider in the solution approach. These examples help the user develop judgment when deciding on the number and the particular degrees of freedom to be retained, and on how to discretize the distributed mass.

EXISTING PROGRAMS

Various researchers have developed computer programs for structural analysis and design applications. Ginsburg (ref. 3) addressed computer literacy, while Woodward and Morris discussed improved productivity through interactive processing (ref. 4). Wilson and Holt (ref. 5) developed a system for computer-assisted learning in structural engineering. Sadd and Rolph (ref. 6) described the various ways in which design engineers could be trained to use the finite element method. Self-adapting menus for CAD software are covered by Ginsburg (ref. 7).

Bykat (ref. 8) is developing a system that will have features for training, analysis control, and interrogation.

SCOPE, PURPOSE, AND SYSTEM ORGANIZATION

The NASTRAN trainer was designed to be a stand-alone tool. The trainer is user friendly--a knowledge of job control language or the operating system is not required. A user can sit down at a terminal and, in very little time, start solving an example problem. The trainer is organized so that a user must complete the static problems (ref. 2) before the dynamics problems can be accessed. This organization prevents a user who has no familiarity with the finite element method from starting with the dynamics section.

The trainer is organized into three main modules: (1) overview, (2) user's guide, and (3) problem set. Figure 2 shows some details of each module. The user accesses these modules by using the primary menu. More details of the NASTRAN environment sections are given in Figure 3.

EXAMPLE PROBLEMS

The example problems, shown in Figures 4 through 11 and summarized in Table 1, become progressively more difficult to solve. The first problem is a simply supported beam with a single lumped mass at the center.

There are various courses and classes to instruct engineers in solving dynamics problems. These courses usually emphasize the theory. A vital part of solving any large dynamics problems is deciding how many and which degrees of freedom should be retained for the eigenvalue solution. This is usually a matter of judgment, and it takes solving many problems to develop this judgment.

Example 2 was solved using three different approaches. The user was trying to answer some fundamental questions that must be addressed every time a dynamics problem is solved using the finite element method:

- Is the model fine enough?
- Have the distributed masses been lumped into enough locations?
- Have enough degrees of freedom been retained in the eigensolution?

Figure 12 summarizes the different approaches. Table 2 compares the computed three lowest natural frequencies with the exact results.

CONCLUSIONS

An automated training tool that helps engineers become familiar with using NASTRAN to solve dynamic problems has been presented. The tool allows the user to proceed at his own pace by using a set of eight example problems. The examples were selected so that classical solutions are available and displayed, enabling the user to make comparisons.

REFERENCES

1. Grooms, H.R., W.J. Merriman, and P.J. Hinz: An Expert/Training System for Structural Analysis. ASME Conference on Pressure Vessels and Piping, New Orleans, Louisiana, June 1985.

2. Grooms, H.R., P.J. Hinz, and K. Cox: Experiences With a NASTRAN Trainer. 16th NASTRAN Users' Colloquium, Arlington, Virginia, April 1988.

3. Ginsburg, S: Computer Literacy: Mainframe Monsters and Pacman. Symposium on Advances and Trends in Structures and Dynamics, Washington, D.C., October 1984.

4. Woodward, W.S., and J.W. Morris: Improving Productivity in Finite Element Analysis Through Interactive Processing. Finite Elements in Analysis and Design, Vol. 1, No. 1, 1985.

5. Wilson, E.L., and M. Holt: CAL-80-Computer Assisted Learning of Structural Engineering. Symposium on Advances and Trends in Structures and Dynamics, Washington, D.C., October 1984.

6. Sadd, M.H., and W.D. Rolph III: On Training Programs for Design Engineers in the Use of Finite Element Analysis. Computers and Structures, Vol. 26, No. 12, 1987.

7. Ginsburg, S: Self-Adapting Menus for CAD Software. Computers and Structures, Vol. 23, No. 4, 1986.

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Table 1. Example Problems

Example	Description	Significant Features
1	Beam simply supported on both ends with lumped mass in middle	Motion in one plane only, lumped mass only
2	Beam simply supported on both ends with uniformly distributed mass	Motion in one plane only, distributed mass
3	Beam fixed on one end with a lumped mass at the free end	Motion in any direction, lumped mass only
4	Beam fixed on one end with a uniformly distributed mass	Motion in any direction with uniformly distributed mass
5	Rectangular plate clamped on one edge, all other edges free with a uniformly distributed mass	Plate bending with distributed mass
6	Rectangular plate, free-free with uniformly distributed mass	Free-free (implies six modes with zero frequency)
7	Two beams connected by springs, each with distributed and lumped mass	Multibody problem, free-free
8	Problem 7 with a forcing function added	Forcing function

Table 2. Comparison of Natural Frequencies for Example 2

Mode \ Approach	Exact Solution	First Approach	Second	Third
1	9.870	9.867	9.869	9.872
2	39.48	39.19	39.47	39.74
3	88.83	83.21	88.66	93.62

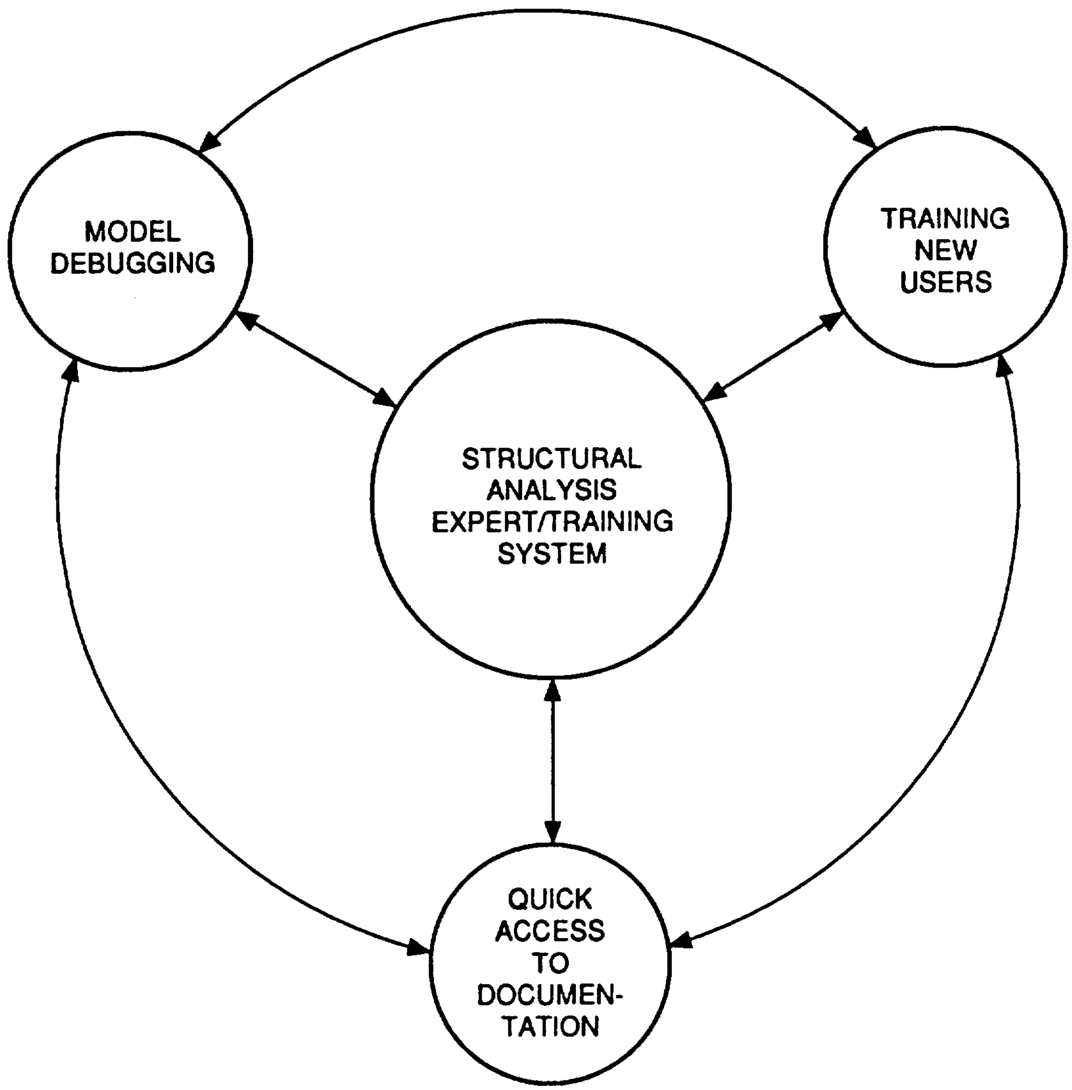


Figure 1. Functional Expert Training System

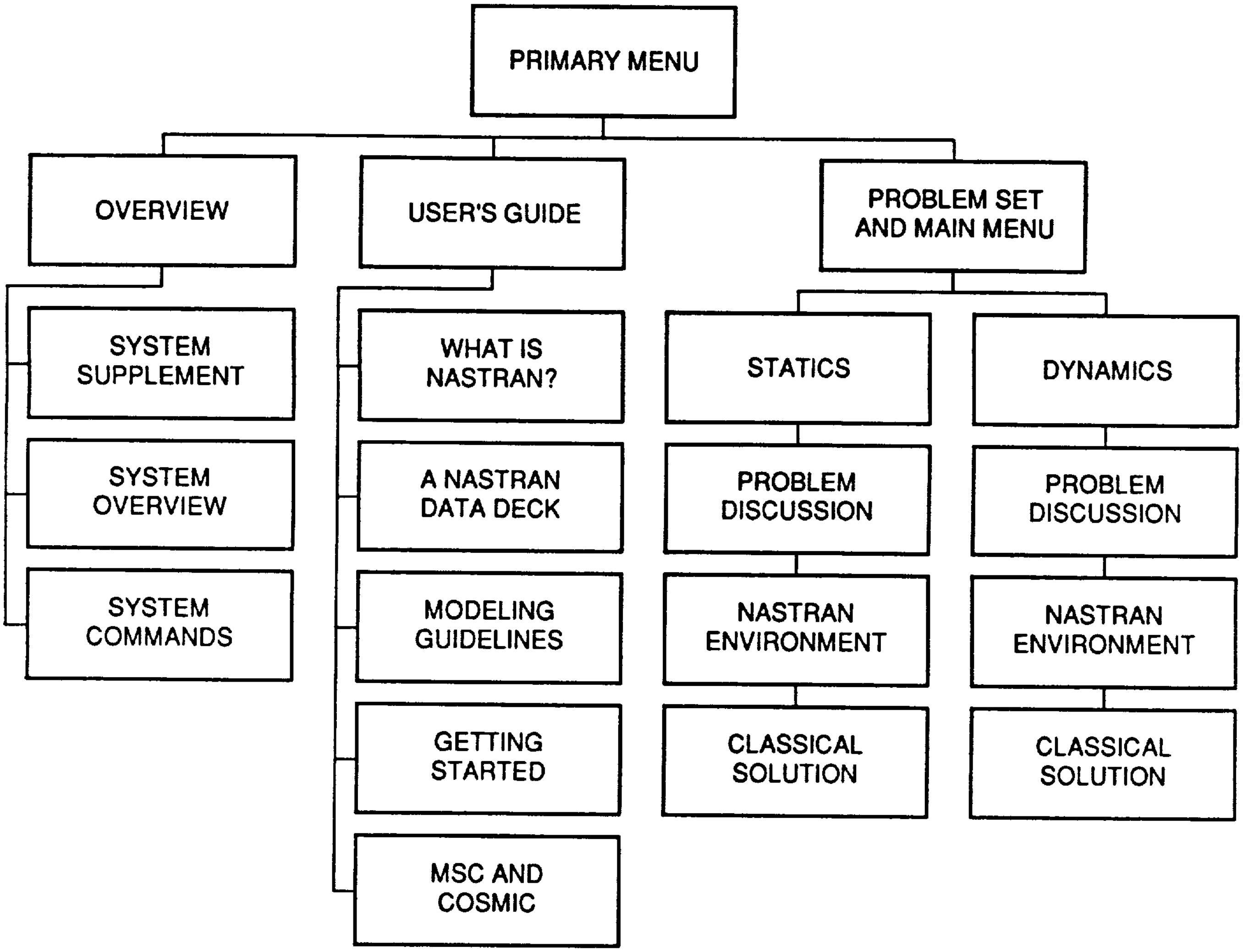


Figure 2. Organization of NASTRAN Trainer

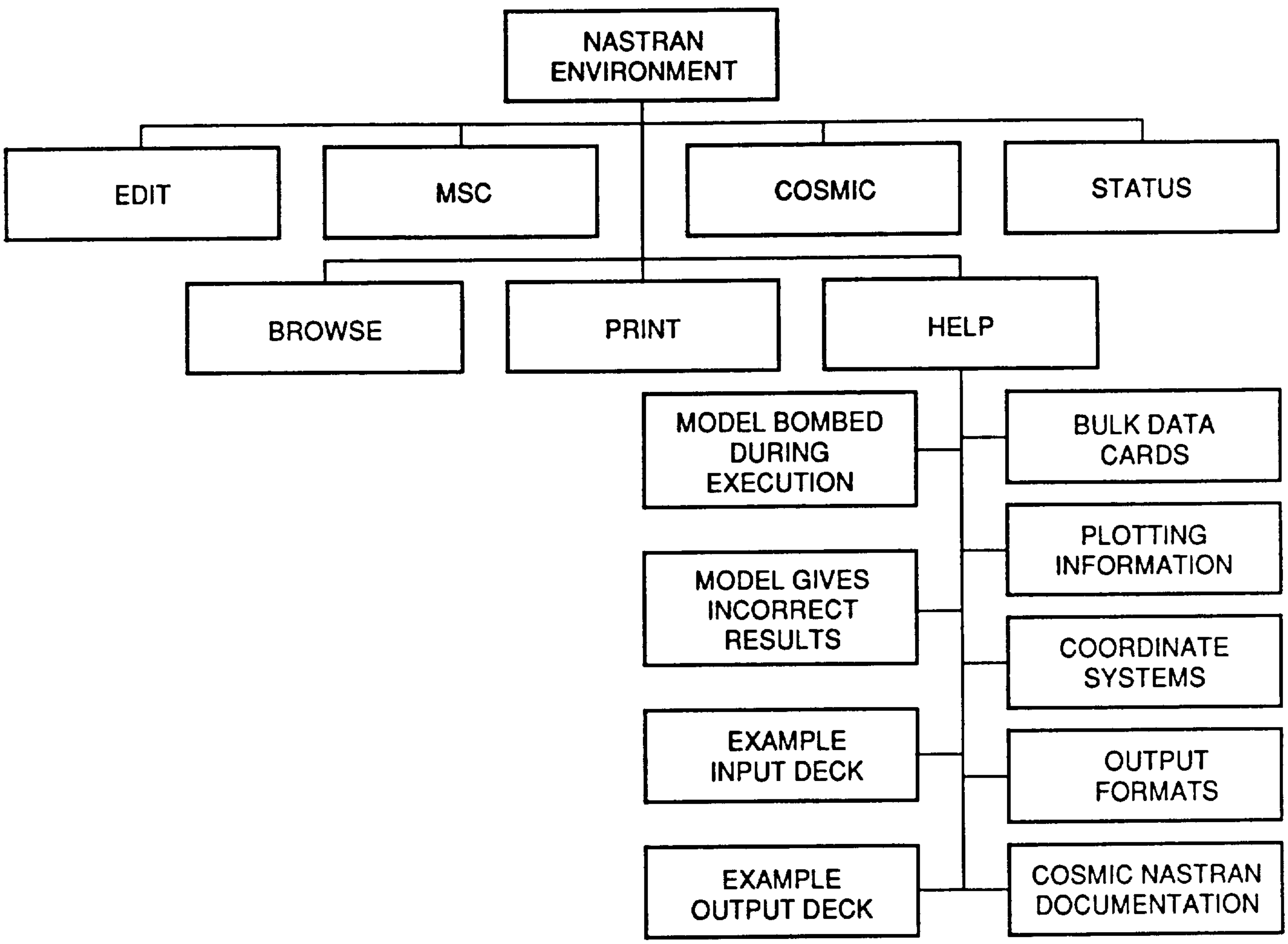


Figure 3. Organization of Program

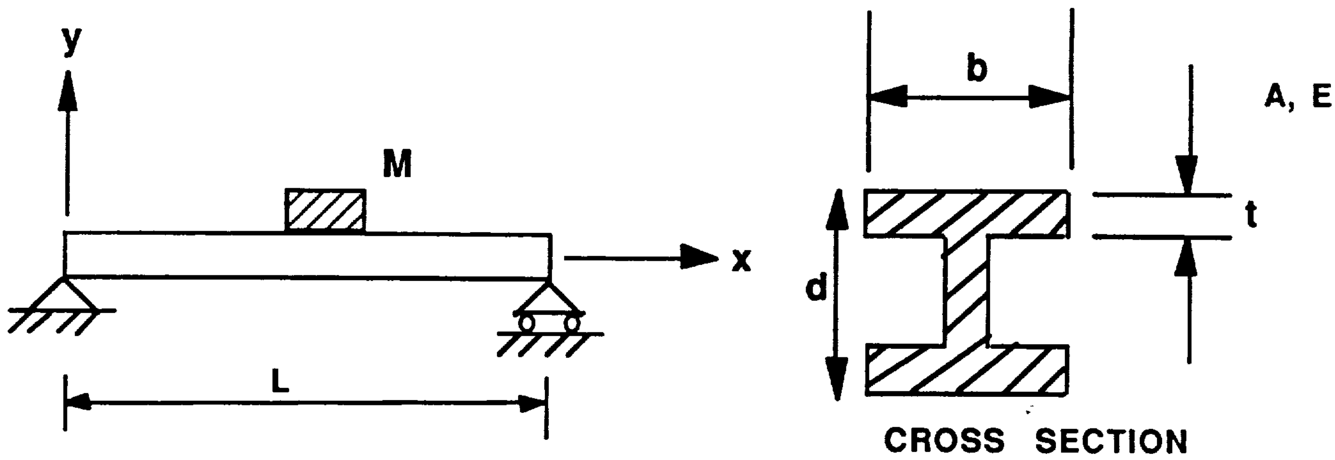


Figure 4. Simply Supported Beam with Concentrated Mass (Example 1)

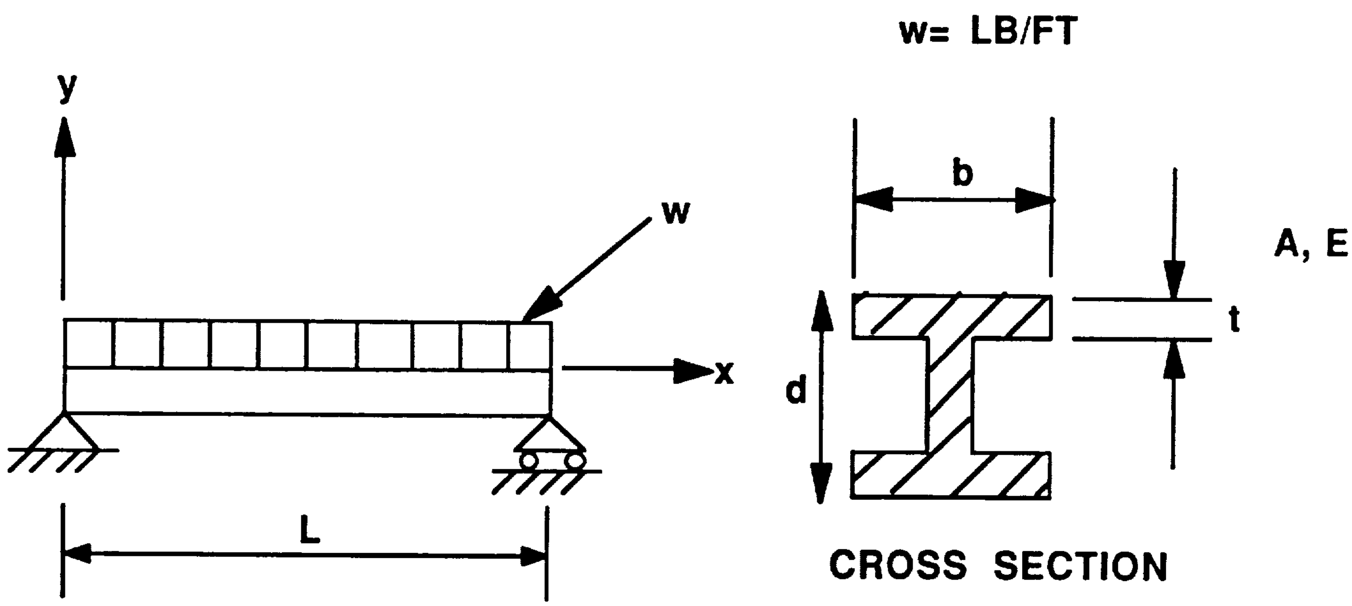


Figure 5. Simply Supported Beam with Uniformly Distributed Mass (Example 2)

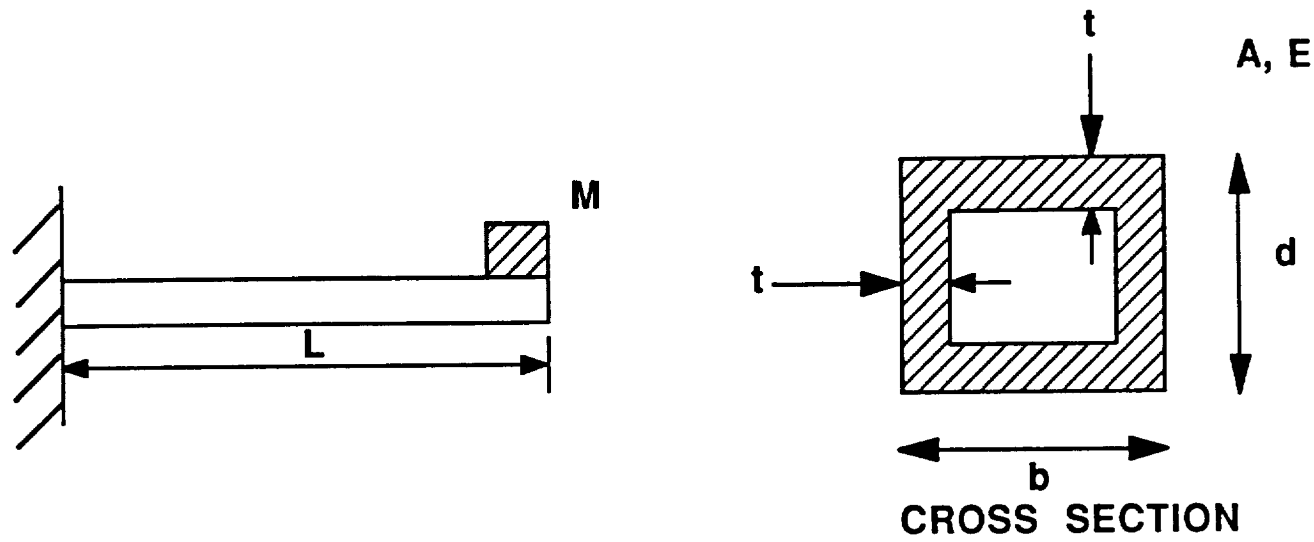


Figure 6. Cantilever Beam with Concentrated Mass (Example 3)

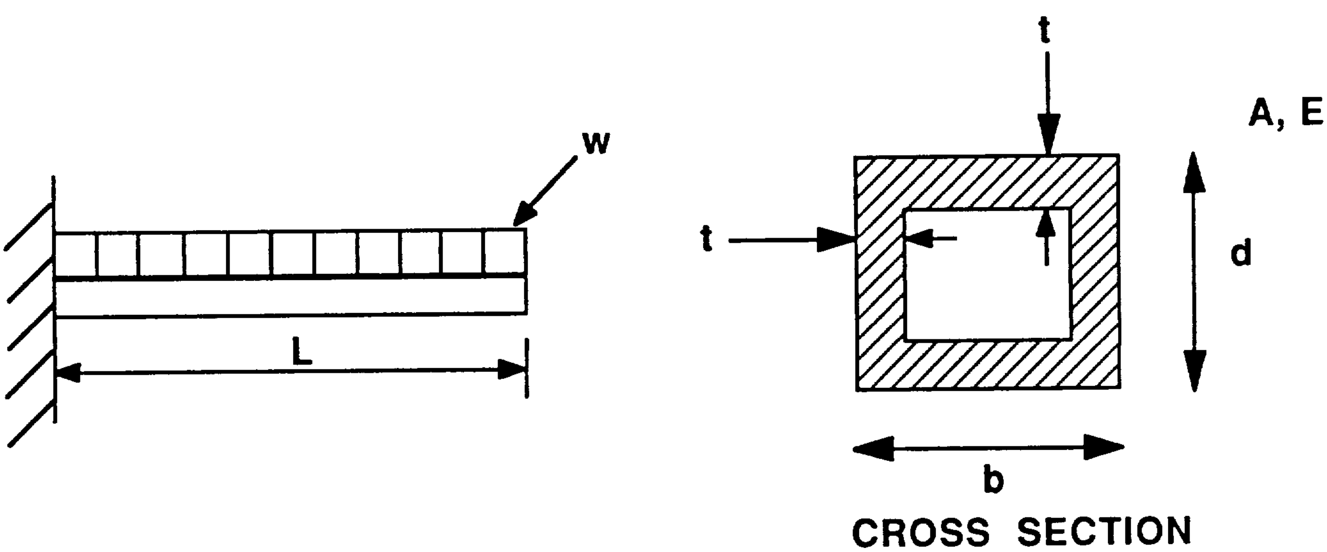


Figure 7. Cantilever Beam with Uniformly Distributed Mass (Example 4)

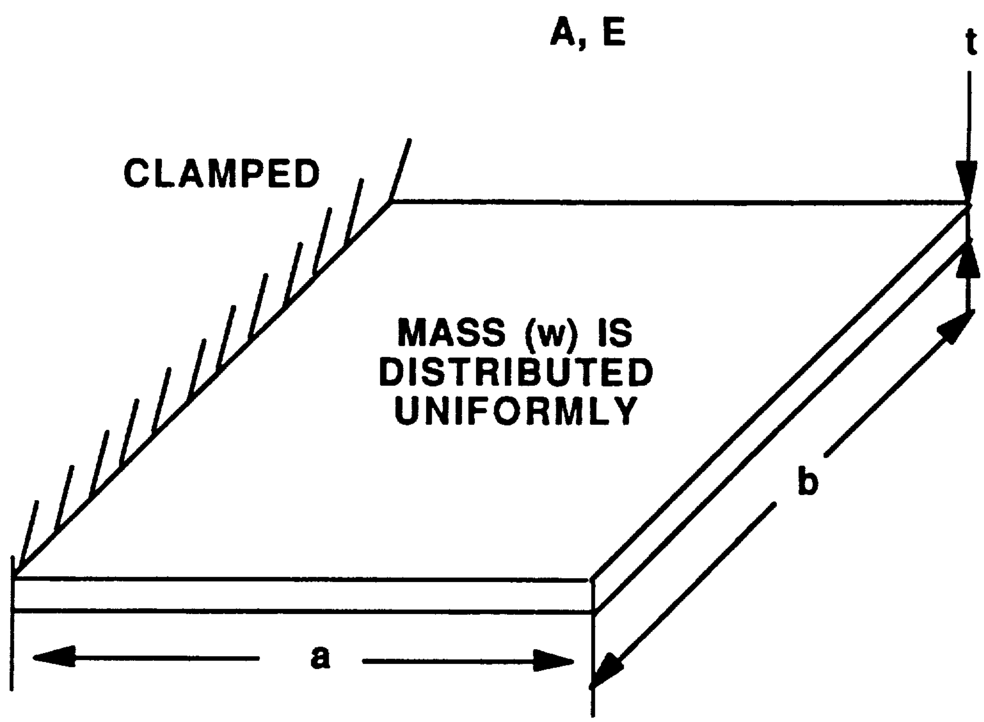


Figure 8. Rectangular Plated Clamped at One Edge (Example 5)

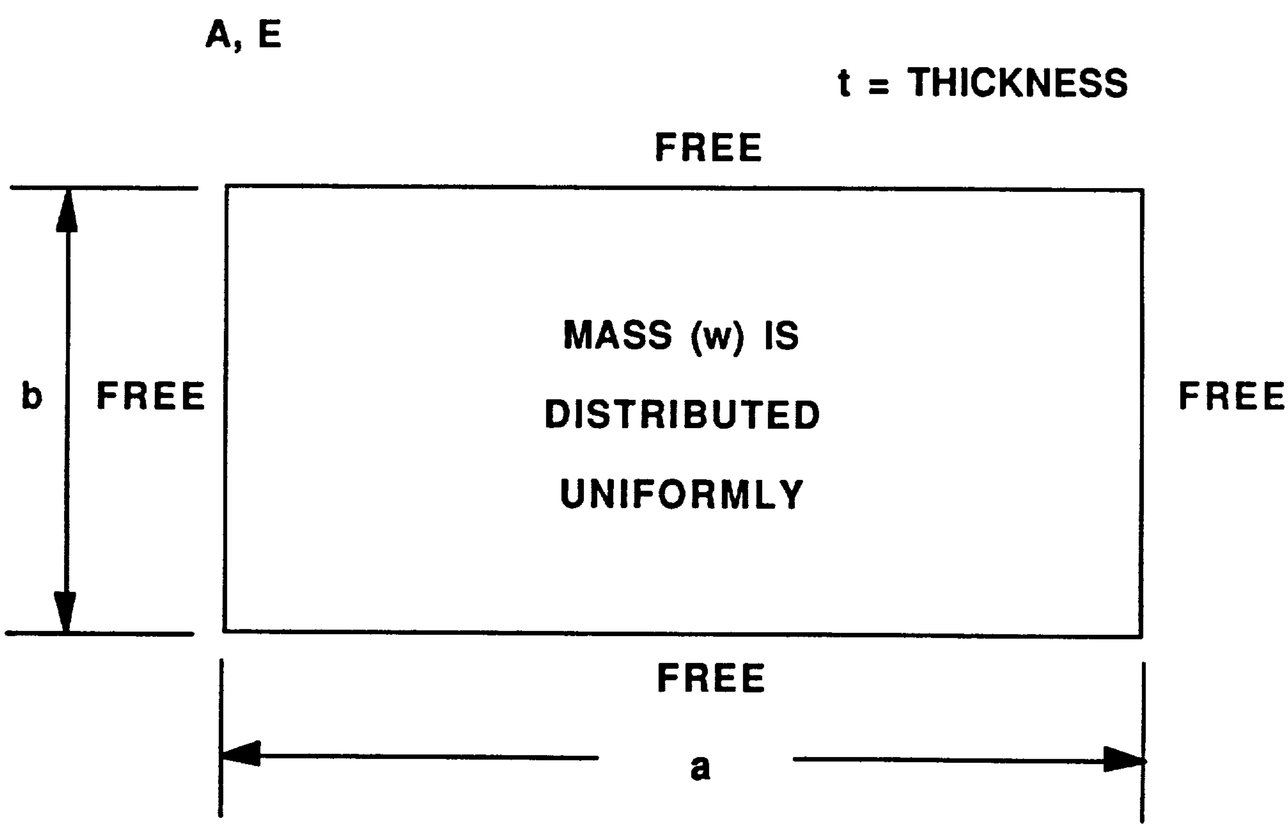


Figure 9. Rectangular Plate Free on All Sides (Example 6)

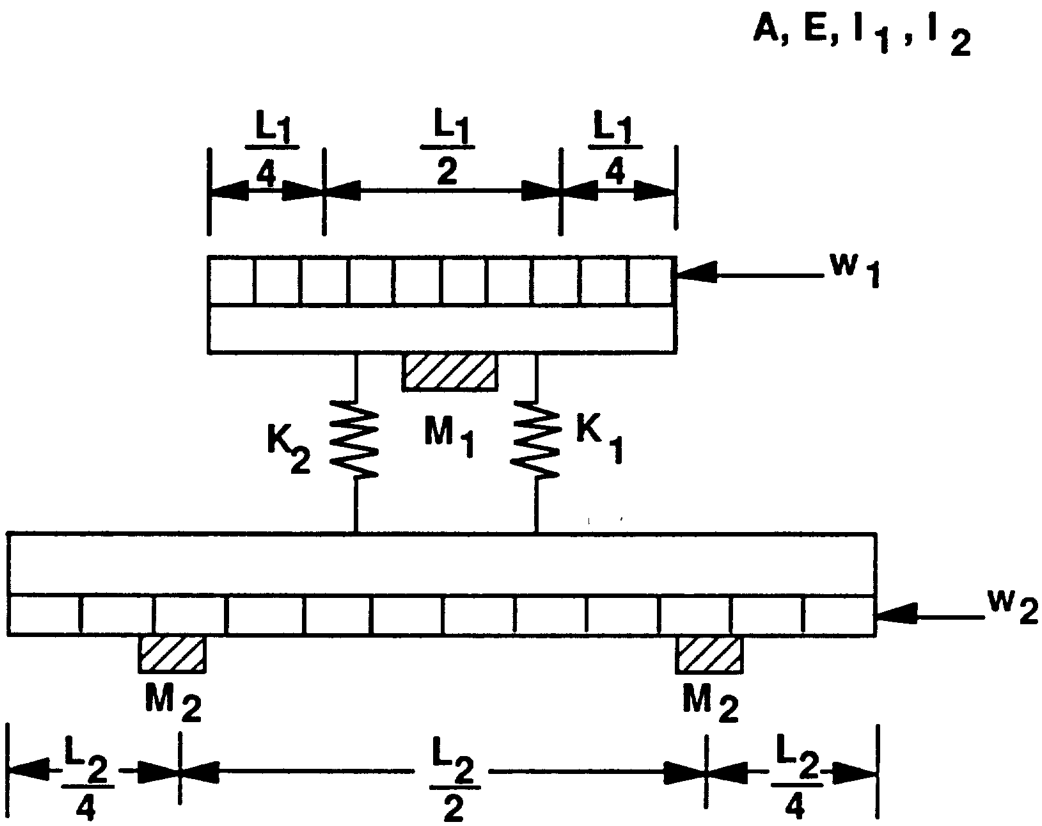


Figure 10. Two Beams Connected by Two Springs (Example 7)

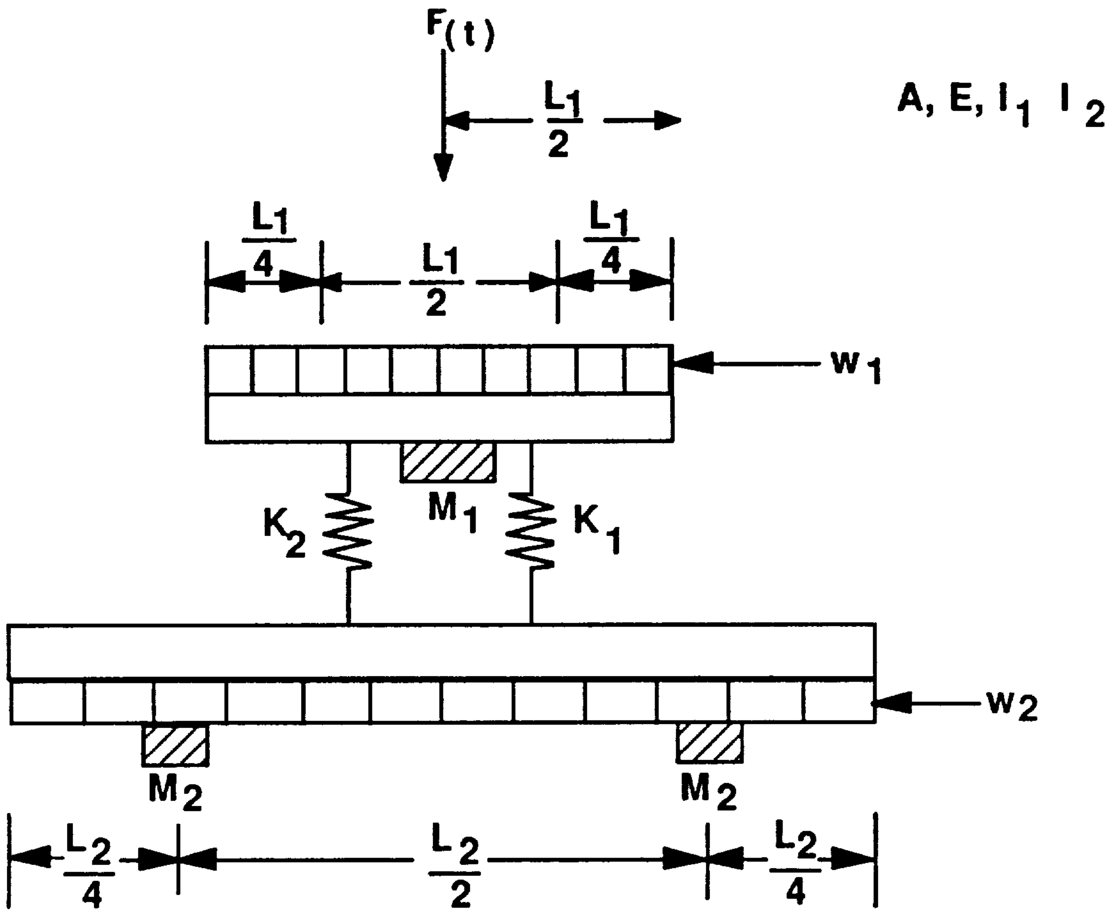


Figure 11. Two Beams Connected by Two Springs Driven by a Forcing Function (Example 8)

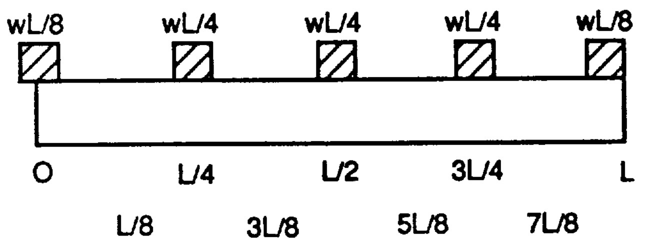
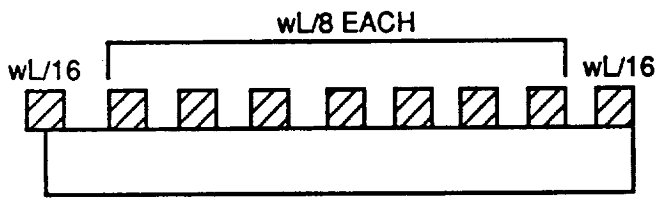
APPROACH		NO. OF ELEMENTS	NO. OF MASSES	DOFs IN EIGEN-SOLUTION
1		4	5	3
2		8	9	7
3	SAME AS APPROACH 2, EXCEPT SAME DOFs SAVED FOR EIGENSOLUTION AS APPROACH 1	8	9	3

Figure 12. Three Approaches to Example 2