

## Design: Methodology and Procedure

This overview of design is intended to supplement your textbook. Although design is not covered explicitly in the text, several problems at the end of each chapter are written to help you develop an approach to solving design problems. These notes will help you identify key features of design problems and develop an effective method for devising an appropriate solution. Notice that the words, “an appropriate solution,” were used instead of “the correct solution.” That is because it is expected that you, the designer, will have options on how to satisfy the design requirements. You may even have to define some of the specifications as you interpret the problem statement. All this variability leads to a host of solutions which meet the design need.

### Background

From the introductory mechanics course, statics, you have studied several approaches for determining forces and moments in structures. Your understanding of how to set up a problem with reactions and applied loads will serve you well for attacking design problems. However, the demanding tasks associated with design are with defining the problem, modeling the real problem with simple components and reactions, and interpreting the results in a meaningful way. The next few sections help to clarify these components and develop an approach.

Before reviewing the approach let’s consider the following three problem statements. Each statement seeks information about the design of a hammock rope, but requires a different thought process.

Analysis (Determinate, one solution):

1. A 200 lb person rests in a hammock that is suspended from two trees that are 8 feet apart. The ropes that attach the hammock to the trees make a 45° angle with the horizontal. Assume the load acts at the center of the hammock and determine the stress in the ropes if the rope diameter is 1/4 inch.

Partial Design:

2. Determine the diameter (to the nearest 1/4 inch) of the nylon rope that will be used to attach a hammock to trees. Assume the rope makes a 45° angle with the horizontal and that the maximum expected load is 300 lb. Also, consider a safety factor of 1.5.

Design (Indeterminate, multiple solutions):

3. A hammock is going to be shipped with all materials needed to set it up--minus the trees, of course. Specify the bill of materials that must be included with the hammock in the package.

These problem statements are used to illustrate and clarify the distinction between design problems and exercises that help develop skills and understanding. For example, problem statement 1 identifies the situation completely. There is only one answer and it will be correct regardless of whether the rope can withstand the load or not. This type of a problem helps to develop important skills: constructing a free-body diagram, satisfying equilibrium and translating a force into stress.

The second problem statement actually has an element of design. The correct solution must take into account the material property and a factor of safety. Most of the information needed is given in the problem statement; however, left to the designer is the task of locating the yield stress of nylon—a material for which there may be a range of values depending on the processing/manufacturing method. Nevertheless, the variability in answers is limited. With this type of problem, the engineering student will gain an appreciation for solving a problem based on meeting a design need—in this case a safe nylon rope to secure a hammock to a tree.

Finally, problem statement 3 opens up a lot of possibilities. The material has not been specified. The angle has not been given. The broad statement that the designer must provide a “bill of materials” indicates that the designer must consider the methods of connection from hammock to rope, and from rope to tree. This type of problem has a wide range of answers, but that is not the only thing that identifies it as a design problem. The solution will require elements of decision making, iterative processes, consideration of standards, and recognition of variable loading and geometry scenarios. In addition, if this is a realistic problem (not an academic exercise) the cost of the materials must be considered and their ability to perform after long periods in the outdoor heat and rain. In the latter, liability considerations will undoubtedly play an important role.

With this brief discussion of features in a design problem, we can look at the design process in more detail and review modeling approaches. Finally, an illustrative example will be used to step through the process. A variety of problems that have elements of design have been identified in your text book and are included at the end of this document.

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