Preface

Engineering mechanics involves the development of mathematical models of the physical world. Statics, a branch of mechanics, addresses the forces acting on and in mechanical objects and systems in equilibrium, and the impact those forces have on the motion, or lack thereof, of those systems. The project deals with the understanding of the mechanical behavior of complex engineering structures and components. The tools of formulating the mathematical equations and the solution methods are discussed. An understanding of forces in and equilibrium of structures and components is most important for their design.

MATLAB is a modern tool that has transformed mathematical methods, because MATLAB not only provides numerical calculations but also facilitates analytical or symbolic calculations using the computer. The present project uses MATLAB as a tool to solve problems. The intent is to show the convenience of MATLAB for theory and applications in statics. This approach will significantly enhance the student's ability to use MATLAB both within statics and beyond. Using examples of problems the MATLAB syntax will be demonstrated. MATLAB is very useful in the process of deriving solutions for any problem in statics. The project will include a large number of problems that are solved using MATLAB. Specific functions dealing with statics topics are introduced and created. The programs will be available on a website accompanying the project.

The main distinction of the study from other projects and books is the use of symbolic MATLAB for both theory and applications. Special attention is given to the solutions of the problems that are solved analytically and numerically using MATLAB. The figures generated with MATLAB will reinforce visual learning for students as they study the programs.

This project is intended primarily for use in a one semester course in statics and could be used in a two semester sequence of courses in statics and dynamics. The project can be used for classroom instruction, for self-study, and in a distance learning environment. It would be appropriate for use as a text at the undergraduate level.

Chapter 1 is intended to give an introduction to vector mechanics. The reason for this chapter is that many scientific concepts used to describe the physical world, have attributes not only of size or magnitude, but also have associated with them the idea of a direction. Examples of such quantities include force, moment, and couple. This chapter provides a starting point for students wishing to develop the basic principle of mechanics. MATLAB is used to calculate the magnitudes of vectors, direction cosines, dot products, cross products, scalar triple products, vector triple products, and derivatives of vector functions. The examples presented begin with a symbolic development, followed by numerical evaluation and the generation of vector figures, all done within MATLAB.

Chapter 2 demonstrates the use of MATLAB in finding the moment of a vector about a point, the moment of a system of vectors, the moment of a couple about a point, the equivalence of systems of vectors, and the force vector and the moment of a force. The figures are depicted using graphical functions built in MATLAB. This chapter also provides an introduction to the basic principles of mechanics.

Chapter 3, centroids and center of mass, presents the principles and details of centroids (also known as the geometric center and connected to the first moment of area) and surface properties, their meaning and importance. All the presentation will be detailed (centroid of a set of points, centroid of a curve, surface or solid, Guldinus-Pappus theorems, parallel-axis theorem) and in some cases followed by examples using MATLAB. External functions can be introduced to calculate the centroids of complex figures. The concepts of the first moment are also useful in analyzing distributed forces.

Chapter 4 analyzes many of the equilibrium problems that are encountered in engineering applications. The equilibrium equations are stated and various types of supports are depicted. The unknown forces and moments acting on bodies are communicated using free-body diagrams and the equilibrium equations are determined. If an object is in equilibrium, the net moment about any point due to the forces and couples acting on the object is zero and the sum of the forces must also be zero. The calculation of moments is explained and the concept of equivalent systems of forces and moments is introduced. In engineering, the term structure can refer to any object that has the capacity to support and exert loads. This chapter studies structures composed of interconnected parts or links. The forces and couples acting on the structure as a total as well as on its individual members are determined. Trusses, which are composed of two-force members, are studied and then frames and machines are considered. MATLAB functions are applied to find and solve the algebraic static equations.

The objective of Chap. 5 is to provide an introduction to friction. Friction forces in engineering applications, have important effects both desirable and undesirable. The Coulomb law of friction is used to find the maximum friction forces that can be exerted by contacting surfaces and the friction forces exerted by sliding surfaces. Threaded connections are also analyzed. MATLAB is used to find friction forces in relation to the associated coefficients of static and kinetic friction.

In the last chapter work and potential energy are described. The work performed when a spring is stretched is stored in the spring as potential energy. Raising an object increases its gravitational potential energy. The principle of virtual work is presented in this chapter. Symbolical and numerical MATLAB are used to solve the examples in this chapter.

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