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INTRODUCTION

Mechanics is the science of force and motion of matter. Solid mechanics is the science of force and motion of matter in the solid state. Physicists are of course interested in mechanics. The greatest advances in physics in the twentieth century are identified with mechanics: the theory of relativity, quantum mechanics, and statistical mechanics. Chemists are interested in the mechanics of chemical reaction, the formation of molecular aggregates, the formation of crystals, or the creation of new materials with desirable properties, or polymerization of larger molecules, etc. Biologists are interested in biomechanics that relates structure to function at all hierarchical levels: from biomolecules to cells, tissues, organs, and individuals. Although a living cell is not a homogeneous continuum, it is a protein machine, a protein factory, with internal machinery that moves and functions in an orderly way according to the laws of mechanics. Therefore, all scientists are interested in mechanics and mechanics is developed by scientists continuously.

Engineers, especially aeronautical, mechanical, civil, chemical, materials, biomedical, biotechnological, space, and structural engineers, are real developers and users of fluid and solid mechanics because of their professional needs. They design. They invent. They are concerned about the safety and economy of their products. They want to know the function of their products as precisely as possible. They want results fast. They experiment. They theorize. They test, compute, and validate. To them mechanics is a toy, a bread and butter, a feast or delicacy.

Engineering is quite different from science. Scientists try to understand nature. Engineers try to make things that do not exist in nature. Engineers stress invention. To embody an invention the engineer must put his idea in concrete terms, and design something that people can use. That something can be a device, a gadget, a material, a method, a computing program, an innovative experiment, a new solution to a problem, or an improvement on what is existing. Since a design has to be concrete, it must have its geometry, dimensions, and characteristic numbers. Almost all engineers working on new designs find that they do not have all the needed information. Most often, they are limited by insufficient scientific knowledge. Thus they study mathematics, physics, chemistry, biology and mechanics. Often they have to add to the sciences relevant to their profession. Thus engineering sciences are born.

This book is written by engineering scientists, for engineering scientists, and this determines its style. The qualities we want are:

- Easy to read,
- Precise, concise, and practical,
- First priority on the formulation of problems,
- Presenting the classical results as gold standard, and
- Numerical approach as everyday tool to obtain solutions.

If the book is a banquet, we offer some hors d'oeuvres in this introductory chapter.

1.1. HOOKE'S LAW

Historically, the notion of elasticity was first announced in 1676 by Robert Hooke (1635–1703) in the form of an anagram, *ceiiinosssttuv*. He explained it in 1678 as

Ut tensio sic vis ,

or "the power of any springy body is in the same proportion with the extension."†

As stated in the original form, Hooke's law is not very clear. Our first task is to give it a precise expression. Historically, this was done in two different ways. The first way is to make use of the common notion of "springs," and consider the load-deflection relationship. The second way is to state it as a tensor equation connecting the stress and strain. Although the second way is the proper way to start a general theory, the first, simpler and more restrictive, is not without interest. In this section, we develop the first alternative as a prototype of the theory of elasticity.

Let us consider the static equilibrium state of a solid body under the action of external forces (Fig. 1.1:1). Let the body be supported in some manner so that at least three points are fixed in a space which is described with respect to a rectangular Cartesian frame of reference. We shall make three basic hypothesis regarding the properties of the body under consideration.

(H1) *The body is continuous and remains continuous under the action of external forces.*

†Edme Mariotte enunciated the same law independently in 1680.