Preface

All what is necessary is simple and all what is too complex is not necessary
Nikolay Timofeev – Resovsky

To clarify the main objective of this book, we would like to compare the viewpoints of two famous Russian scientists.

A.M. Lyapunov wrote that after its formulation, every mechanical problem has to be solved analytically as a problem of pure Mathematics in all its rigor, no matter how complex this problem will be. The idea of N.E. Zhukovsky was that mechanicians have to derive the equations reasonably simple to be integrated and analyzed.

It is now clear that the first viewpoint in its initial meaning turned out to not be realistic, since many important mechanical problems do not allow any rigorous mathematical treatment. Besides, all mathematical formulations of real-world problems are based on approximate physical models. Should one strive for complete mathematical rigor if the accuracy of conclusions anyway cannot exceed that of the initial model?

As for the viewpoint of N.E. Zhukovsky, its direct application to the contemporary situation may lead to somewhat paradoxical conclusions. Indeed, it sometimes seems that there is no need in Mechanics at all because almost any reasonable mathematical formulation of any mechanical problem can be explored numerically to large extent. Therefore, almost any model with any initial and boundary conditions can eventually be integrated.

As we can see, the two viewpoints have some point of convergence – almost any problem can to some extent be examined numerically as a purely mathematical one and very often almost nothing is available beyond these numerical results. This convergence of both viewpoints led to the absolute domination of numerical simulation in Mechanics.

There is no need to explain the strength of numerical methods in mechanical problems, but some concerns should be mentioned. Sometimes one reads papers which try to solve a certain mechanical problem numerically while taking as many factors as possible into account without checking their relative significance.

Consequently, the investigator obtains a huge amount of numerical information but fails to interpret the results – despite all efforts, no understanding of the mechanical situation is gained. In fact, a lot of papers are published with rather sophisticated calculations that add nothing to our knowledge.

We suppose that the main goal of Mechanics is to develop the models providing an understanding. The latter concept is rather vague; therefore we try to refine it by using the term "tractable model". The model is considered to be tractable if it is based on clear physical assumptions, which allow the selection of significant effects and a relatively simple mathematical formulation. These models may be obtained either by phenomenological consideration (based on some physical hypotheses) or by asymptotic reduction of a more general and often non-tractable model. The mathematical formulation should be simple enough to provide direct relationship between the results (no matter if analytic or numeric) and the initial assumptions. The principal point is that the mathematical analysis of a tractable model has to deliver a clear sense of the mechanical phenomenon described by it, providing genuine understanding. As this takes place, computer simulation is a powerful tool for examination, confirmation and sometimes for refutation of the hypotheses used to formulate the model.

Successful tractable models are important milestones in any field of exact science. Besides a wide field of application for the model itself, one often uses it for comparison with the results provided by more refined models.

Very often, the tractable models have a clear asymptotic nature. Historically, some of them appeared as a result of a mere guessing of appropriate asymptotics; others appeared with the help of regularized construction of the asymptotics. The development of tractable models, including their formulation, analysis and interpretation often leads to surprises and paradoxes.

This book tries to describe some of the significant tractable models widely used in modern solid mechanics as well as some new ones. The models are selected in order to illustrate main ideas which allowed scientists to describe complicated effects in a rather simple manner and to clarify basic notions of Solid Mechanics. Of course, the choice of the models is sole responsibility of the authors and no attempt is made to cover the whole variety of mechanical models.

We restrict ourselves to problems related to mechanics of solids. The book is divided into four chapters. The first chapter is introductory and reviews the historical development of basic models in Solid Mechanics in general. The second chapter is devoted to a more or less systematic review of the models with finite number of the degrees of freedom. The third chapter deals with some infinite discrete systems, such as chains and systems of these chains. The fourth chapter treats some continuous models.

Some results and models presented in this book were obtained and formulated by the authors, in cooperation with a number of other scientists. At this opportunity, we would like to reveal our deep gratitude to our numerous co-authors, whose names can be found in the references.

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