Preface

The prediction of the response of a material (or a structure) to external loading is an ordinary engineering problem. It is a necessary step in the design of any man-made tools, devices, and constructions. Increasing complexity of advanced electronics, modern machinery and equipment, and of corresponding materials demands more and more sophisticated methods for their proper handling. The accuracy in the prediction of the material behavior depends on the chosen theoretical description. It is well understood that idealized classical theories (like linear elasticity and Fourier's heat conduction) work well if a material can be considered as homogeneous and a loading is not extremal. Such theories are not sufficient for inhomogeneous microstructured materials. At the same time, the complete atomistic (or even quantum mechanics) exposition is possible only in principle and in any case it is difficult for using in practice. The compromise between the full accuracy and a practical treatment can be achieved in various ways. One of such possibilities is presented in this book.

The considered approach supposes the introduction of internal variables to characterize the influence of a microstructure on the global behavior of a material. This idea is not new and has been exploited at least for 50 years. It was broadly applied in rheology, plasticity, and phase-field theory. However, its full power was uncovered only recently. The use of the internal variable concept in a more extended context, i.e., the introduction of a dual internal variable, provides a unified treatment both internal variables of state and dynamic degrees of freedom. This extension covers both parabolic evolution equations for dissipative internal variables and hyperbolic evolution equations in the absence of dissipation. Both forms of evolution equations follow from the dissipation inequality and, therefore, are thermodynamically consistent. The structure of well-known evolution equations for the Cosserat microrotation and for the micromorphic microdeformation is recovered in the framework of the proposed approach. In the case of heat conduction, a hyperbolic evolution equation for the microtemperature is obtained by keeping the coupled parabolic equation for the global temperature.

Thus, the framework of the construction of advanced continuum theories is described and illustrated in the book. The coupling between mechanical and thermal effects is treated in the dynamic context. Static problems are omitted due to their relative simplicity. The three-dimensional theory is complemented by examples in the one-dimensional case. An implementation of the theory into numerical algorithm is provided as well.

The book summarizes results obtained during the collaboration between co-authors in the framework of joint Estonian–Hungarian research projects under the agreement of scientific cooperation between the Estonian and Hungarian Academies of Sciences.

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This book is intended for graduate and postgraduate students and scientists in the area of applied mathematics, mechanics, and engineering sciences, who are acquainted with the basics of mechanics of continuous media.

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