Part II
Foundations

Abstract In the second part of the book, we summarize the most important theoretical principles that are used throughout the book. First, analytical approaches to describe the wave propagation in elastic solids are discussed. Based on Navier's wave equation different types of waves existing in isotropic, anisotropic, and layered solids are identified.

Second, we introduce the finite element method (FEM) as a universal tool for computational mechanics that is principally capable of solving all wave propagation related tasks. As a wide variety of efficient numerical methods that is deployed to analyze the wave propagation numerically is based on the FEM we discuss the weak from of the equilibrium equations and derive the semi-discrete form of the equations of motion. These can be efficiently solved by deploying explicit time-integration methods in conjunction with suitable mass-lumping techniques. Therefore, we briefly discuss time integration and established lumping schemes generating a diagonal mass matrix.

Finally, we introduce experimental methods that are commonly used to measure ultrasonic guided waves. Techniques such as air-coupled ultrasound and Laser Doppler vibrometry are explained in detail.