VISCOELASTIC MATERIALS

Understanding viscoelasticity is pertinent to design applications as diverse as earplugs, gaskets, computer disks, satellite stability, medical diagnosis, injury prevention, vibration abatement, tire performance, sports, spacecraft, and music. This book fits a one-semester graduate course on the properties, analysis, and uses of viscoelastic materials. Those familiar with the author's precursor book, *Viscoelastic Solids*, will see that this book contains many updates and expanded coverage of the materials science, causes of viscoelastic behavior, properties of materials of biological origin, and applications of viscoelastic materials. The theoretical presentation includes both transient and dynamic aspects, with an emphasis on linear viscoelasticity to develop physical insight. Methods for the solution of stress analysis problems are developed and illustrated. Experimental methods for characterization of viscoelastic materials are explored in detail. Viscoelastic phenomena are described for a wide variety of materials, including viscoelastic composite materials. Applications of viscoelasticity and viscoelastic materials are illustrated with case studies.

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In ancient rivalry with fellow spheres the sun still sings its glorious song and completes with tread of thunder the journey it has been assigned.

Goethe

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Preface

This book is intended to be of use in a one-semester graduate course on the properties, analysis, and uses of viscoelastic materials. A precursor book, *Viscoelastic Solids*, has been used as a text in such a course. This book contains many updates, expanded coverage of the materials science of the causes of viscoelastic behavior, and of the properties of materials of biological origin, and applications of viscoelastic materials. The objective is to make the subject accessible and useful to students in a variety of disciplines in engineering and physical science. To that end, the coverage is intentionally broad. For research scientists and engineers or graduate students who pursue the subject via self-study, many references have been included to provide links to the literature. The subject may be profitably studied by undergraduate students, particularly those who are interested in vibration abatement, biomechanics, and the study of materials. Most of the book should be accessible to people who have completed an intermediate or an elementary course on the mechanics of deformable bodies. Exposure to elasticity theory, materials science, and vibration theory is helpful but not necessary.

A development of the theory is presented, including both transient and dynamic aspects, with emphasis on linear viscoelasticity. The structure of the theory is presented with the aim of developing physical insight. Methods for the solution of stress analysis problems in viscoelastic objects are developed and illustrated. Experimental methods for characterization of viscoelastic materials are explored in detail. Viscoelastic phenomena are described for a wide variety of materials, including polymers, metals, ceramics, geological materials, biological materials, synthetic composites, and cellular solids. High-damping alloys and composites are considered as well as materials that resist creep. To illustrate the sources of viscoelastic phenomena, we describe and analyze causal mechanisms, with cases of materials of extremely high damping and extremely low damping. The theory of viscoelastic composite materials is presented, with examples of various types of structures and the relationships between structure and mechanical properties. Many applications of viscoelasticity and viscoelastic materials are illustrated, with case studies and analysis of particular cases. Viscoelasticity is pertinent to applications as diverse as earplugs, gaskets, computer disks, satellite stability, medical diagnosis, injury

prevention, vibration abatement, tire performance, sports, spacecraft, and music. Examples of the use of viscoelastic materials in the prevention and alleviation of human suffering are explored. Supplementary material, including audio and video demonstrations of viscoelastic behavior, class resources, and research links, are provided on the following Website: `http://silver.neep.wisc.edu/~lakes`.

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