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Quasistatic contact problems in viscoelasticity and viscoplasticity. (English. English summary)
AMS/IP Studies in Advanced Mathematics, 30.
American Mathematical Society, Providence, RI; International Press, Somerville, MA, 2002. xviii+442 pp. \$79.00. ISBN 0-8218-3192-5
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The discipline of mathematical theory of contact mechanics has emerged from its infancy, and is growing rapidly both in scope and in depth. However, recent publications can be found in a wide range of mathematical and applied, mainly engineering, journals, and a need for a clear unified presentation of the many results has been recognized.

This need is, in part, fulfilled by this monograph, which presents in a unified way a comprehensive collection of very recent results on models dealing with quasistatic contact between viscoelastic or viscoplastic bodies. This makes the results easy to access and study.

This monograph is intended first and foremost for the professional or the advanced student whose main interest is the analysis, numerical analysis and numerical simulations of variational models for contact processes. Some background in modelling is provided, and so is the necessary preliminary mathematical material. Then, an explanation of the applications of the finite element method is given. In this manner the book is essentially self contained, and is very likely to become an important and very useful tool in the further research of contact problems, variational inequalities and their numerical analysis. Moreover so, since it presents novel algorithms for contact problems with proven convergence and error estimates, which is a very recent topic of considerable applied importance.

The models for quasistatic contact processes are described by variational inequalities, and the intimate connection between the mathematical theory of contact mechanics, the theory of variational inequalities and the numerical analysis of variational inequalities is clearly evident in the book, as the topics are interlaced throughout the exposition.

The main topics of the book are the mathematical analysis of models for viscoelastic and viscoplastic contact problems, construction of numerical algorithms for their computer simulations, and the numerical analysis of these algorithms. The proofs of the existence of solutions, their uniqueness, the convergence of the algorithms and error estimates are provided in full detail.

The book is divided into four parts. The first two deal with preliminary material, and the last two contain the main topics of the monograph.

Part I, "Nonlinear variational problems and numerical appproximation", provides an introduction of the necessary concepts in functional analysis, finite element approximations and elliptic and evolution variational inequalities. In Part II, "Mathematical modelling in contact mechanics", the authors provide an introduction to models of mechanical contact, and describe the viscoelastic and viscoplastic constitutive relations. Then they provide an overview of semi-discrete and fully-discrete finite element approximations of contact problems. For the benefit of the reader, they also describe some results on the contact of elastic materials.

Now, Parts III and IV are where the main interest of the book lies. Each one is divided into five

chapters, and these have a similar structure. First comes the classical statement of the problem and its variational formulation, then the statement of the existence and possible uniqueness of the weak solution, and then the proof of the theorem is given. Next, semi- or fully-discretized finite element approximations, the proof of convergence and some error estimates are to be found. For some of the problems dual formulations, in terms of the stresses, are provided and analyzed, too. For a few of them numerical simulations are depicted.

Part III, "Contact problems in viscoelasticity", is dedicated to viscoelastic problems. The first four chapters deal with: frictionless contact, bilateral contact with slip dependent friction, frictional contact with normal compliance, and frictional contact with damped normal response. The last chapter deals with nonlocal friction, wear and a dissipative friction potential. Two abstract theorems, motivated by the problems, can be found in the third and fourth chapters, and some numerical simulations of the solutions are depicted there, too.

Part IV, "Contact problems in viscoplasticity", deals with viscoplastic problems. The chapters deal with the Signorini contact, frictionless contact with dissipative potential, frictionless contact between two viscoplastic bodies, and bilateral contact with Tresca's friction law. The last chapter deals with a simplified friction law, a dissipative friction potential, a stress formulation in perfect plasticity, and with a frictionless contact problem with internal variables. Some numerical examples are provided in the second and third chapters.

The two-way link between contact mechanics and the theory of variational inequalities can be found throughout the book. In two of the the chapters general abstract theorems are established, and then applied to the problems-at-hand. The motivation for these abstract results came from the problems, and in this way, new theorems which extend the theory have been proven, based on an applied need and not on an ability to slightly improve or generalize a known theorem.

The book is well written, attests to the high level of sophistication the discipline has achieved, and certainly is a welcome and important addition to the field.

Reviewed by Meir Shillor