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Modeling and Simulation of Tribological Problems in Technology

Springer

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Preface

Significant advances in contact mechanics have been achieved since the first theoretical derivations 130 years ago with Hertz, primarily associated with the solution of contact problems in statics and dynamics involving later on friction, adhesion, wear, roughness, heat or electric conduction, and also with materials not only linear elastic. Principles of contact mechanics can be applied in many traditional mechanical engineering areas such as locomotive wheel–rail contact, coupling devices, braking systems, tires, bearings, combustion engines, mechanical linkages, gasket seals, metal forming, ultrasonic welding, electrical contacts, and many others. Current challenges in the field regard to the extension of contact mechanics methodologies to the micro- and the nanoscale, to coupled multi-field problems, and to advanced mechanical engineering, microelectronics, and nanomechanics applications involving roughness, adhesion, friction, and wear.

With the goal to convey, in a self-contained manner, the fundamental concepts for the classification of the types of contact, the mathematical methods for the formulation of the contact problems, and the numerical methods required for their solution, we organized a course on "Modelling and simulation of tribological problems in technology" in the International Centre for Mechanical Sciences (CISM) in Udine, Italy, from May 28 to June 1, 2018. Such a course featured 5 days of lectures delivered by A. Almqvist (Luleå University of Technology, Sweden), J. R. Barber (University of Michigan, USA), D. Dini (Imperial College London, UK), D. A. Hills (University of Oxford, UK), and M. Paggi (IMT School for Advanced Studies Lucca, Italy) to an audience of more than 40 researchers from academia and industry.

As a consequence, this book and its seven chapters—based on the lectures of the aforementioned CISM course—aim at conveying a strong background on the theory and numerical methods for contact mechanics, with also the in-depth treatment of cutting-edge research topics and applications. The book is primarily tailored for doctoral students of applied mathematics, mechanics, engineering, and physics with a strong research interest in theoretical modeling, numerical simulation, and experimental characterization of contact problems in technology. It is also suited for young and senior researchers in the above-mentioned and neighboring

fields working in academia or in private research and development centers, interested in gaining a compact yet comprehensive overview of contact mechanics from its fundamental mathematical background, to the computational methods and the experimental techniques available for the solution of contact problems.

As a start, Chap. 1 "Fundamentals of Elastic Contacts" provides a classification of contact problems and the half-space solutions for linear elasticity. For the class of complete contacts, asymptotic methods are formulated and applied to mechanical engineering problems. Chapter 2 "Contact Problems Involving Friction" further extends the discussion to contact problems with friction and partial slip, with attention to coupling between the normal and the tangential contact problems, also in elastodynamics. Chapter 3 "Nonequilibrium Molecular Dynamics Simulations of Tribological Systems" focuses on modeling contact problems at the nanoscale, exploiting nonequilibrium molecular dynamics methods. Chapter 4 "Computational Methods for Contact Problems with Roughness" introduces computational methods for the solution of normal and tangential contact problems at the microscale, with special attention to modeling of surface roughness. Chapter 5 "Emergent Properties from Contact Between Rough Interfaces", exploiting the methods presented in the previous chapter, focuses on the key research question of how nonlinear interactions between contact patches induced by roughness across different length scales influence the emergent physico-mechanical properties of an interface. Chapter 6 "Modelling Flows in Lubrication" introduces the reader to lubrication theory and describes the governing equations, models and methods that can be used to simulate various types of lubricated systems. Finally, Chap. 7 "Contact Mechanics of Rubber and Soft Matter" focuses on the role of viscoelasticity and adhesion in contact problems, the methods for their solution and also the characterization of the phenomenon of energy dissipation in tangential contacts.

We would like to thank all the colleagues for their great efforts and dedication to share their knowledge, and their engagement in the CISM lectures and the contributions to this book.

Lucca, Italy — Marco Paggi
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