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Ю. И. НЕЙМАРК и Н. А. ФУФАЕВ

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PREFACE

The idea of writing the present book arose during A. A. Andronov's seminar in 1949/50 in connection with the discussions on the formulation of the equations of motion of various technical systems. Apart from furthering scientific aims, the seminar was intended to serve a pedagogical purpose, as was emphasized more than once by Professor Andronov. Among the subjects discussed were the concepts of directed couplings and servo constraints, methods of formulating the equations of electrical circuits, tensor forms of equations of motion, equations of motion of mechanical systems, variational principles of field theory and electrodynamics, questions of the derivation of the equations of motion of electrical machines, and many other problems. Papers were read at the seminar by N. A. Železcov, M. L. Levin, A. V. Gaponov, Ju. I. Neĭmark, N. A. Fufaev, and others. It was during this seminar that certain inaccuracies in a number of works on the mechanics of nonholonomic systems came to light and a connection was revealed between the theory of electrical machines and the mechanics of nonholonomic systems.

Work on a book on the dynamics of nonholonomic systems begun in 1951 by Neĭmark had to be discontinued for a number of reasons. Much later, the authors were again attracted to problems of the mechanics of nonholonomic systems and they published a number of papers concerning the derivation of equations of motion, the applicability of mathematical models in the mechanics of nonholonomic systems, the stability of nonholonomic systems, and the directional stability of rolling systems. Not surprisingly, the idea of writing a book was revived and this time bore fruit.

Between the conception and completion of the book, its plan has undergone certain changes, but the general idea, namely, to bring together and unite the abstract theory of analytic mechanics and the applied problems of stability of rolling systems and the theory of electrical machines, has been preserved. The desire to present the concrete applications as fully as possible has also been preserved and is reflected in the selection of a large number of examples.

Inevitably, the attention devoted to the various aspects of the subject has been determined to a certain extent by the personal scientific

interest of the authors. As a result, many questions either have remained untouched or have not been treated as comprehensively as they warrant.

The same applies to the bibliography, which is extensive, but can in no way pretend to be exhaustive.

The book gives the first comprehensive and systematic exposition of the mechanics of nonholonomic systems, including the kinematics and dynamics of nonholonomic systems with classical nonholonomic constraints, the theory of the stability of nonholonomic systems, technical problems of the directional stability of rolling systems, and the general theory of electrical machines.

The first chapter consists of an exposition of the kinematics of nonholonomic systems. The fundamental concepts are introduced and the criterion of holonomy of kinematic constraints is established. The chapter is concluded with the theory of kinematic integrating mechanisms.

The second chapter is devoted to the study of the motion of nonholonomic systems on the basis of the general laws of dynamics. Čaplygin's theorem on conservation of angular momentum is generalized and classical problems of rolling of rigid bodies on a surface are studied.

The third chapter is devoted to the analytical mechanics of nonholonomic systems. Different forms of the equations of motion of nonholonomic systems are investigated and the use of transpositional relations is elucidated. Impulsive motions of nonholonomic systems are studied; conditions for the existence of first integrals are derived and an exposition given of the theory of Čaplygin's last multiplier.

The problem of the applicability of mathematical models in the mechanics of nonholonomic systems is studied in the fourth chapter. The influence of small parameters on the dynamics of nonholonomic systems is studied in a number of specific examples.

The fifth chapter is devoted to the stability and small oscillations of nonholonomic systems about equilibrium positions and also about steady motions.

In the sixth chapter the general equations of motion of a vehicle on wheels with pneumatic tires are derived. A number of specific technical problems of the directional stability of rolling systems are considered. These include the bicycle, motorcycle, automobile, the landing gear of an aeroplane, and a railroad truck.

In the seventh chapter, the dynamics of nonholonomic systems is studied from the point of view of the general theory of electrical machines. The Lagrange-Maxwell equations for electromechanical systems with

closed and open currents are derived on the basis of a discrete description of the electromagnetic processes in the quasi-steady approximation. Examples are given of electromechanical systems with nonholonomic constraints resulting from sliding contacts. The general equations of electrical machines are derived.

The book contains 172 figures and 5 tables, and 515 references are included in the bibliography.

The table of contents will give the reader a fairly complete idea of the contents of the book. We should like to point out that readers who are only interested in certain aspects of dynamics of nonholonomic systems can turn straight to the relevant chapters and use the remaining chapters for reference purposes.

Ju. I. Neĭmark, N. A. Fufaev

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TABLE OF CONTENTS

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The goal of this book is to give a comprehensive and systematic exposition of the mechanics of nonholonomic systems, including the kinematics and dynamics of nonholonomic systems with classical nonholonomic constraints, the theory of stability of nonholonomic systems, technical problems of the directional stability of rolling systems, and the general theory of electrical machines. The book contains a large number of examples and illustrations.

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