Preface

Mechanisms have been used since time immemorial for various tasks. Apart from being indispensable for all kinds of mechanization, mechanisms have always fascinated the human mind. Perhaps, in a very rudimentary sense, mechanisms remotely resemble living objects. In the past, mechanism design and inventing new mechanisms were important activities not only for engineers but also for scientists. In fact, the contributions of mathematicians to mechanism theory have really helped this branch of engineering science grow. With the progress in technology, the role of automation and mechanization increased in importance and courses on Theory of Mechanisms and Machines occupied a major share of all Mechanical and Aerospace Engineering curricula.

However, from the second half of the 1970s and early 1980s a kind of gloom descended on the kinematics community. This was primarily because of the rise of microelectronics, programmable logic controllers, and computer control and numerical control (NC) technology. The need for careful and meticulous mechanism synthesis became redundant as any kind of motion and trajectory could be generated with extreme accuracy using multiple servo drive systems controlled by computers. Many universities the world over gradually removed the subjects in the domain of kinematics and mechanism theory from the curricula. Apart from being very accurate the multiple-drive-based NC motion generation has the added advantage of having the ability to quickly change from one geometric characteristic to another without any change in the hardware. This led many kinematicians to think that 'mechanism theory' was destined to become a dead subject.

Fortunately, along with the computer-based Second Industrial Revolution (which was a threat to the continued existence of the subject) came the trend of miniaturization. Though initially this trend was confined to electronic circuits and devices only, soon it spread to other fields. Now it is felt by many that once miniaturization revolution spreads to other fields the process of the Third Industrial Revolution will begin. The main feature behind the forthcoming revolution in technology will be based on miniaturization of three-dimensional machines and devices capable of manipulating material at the micro, nano, and even molecular levels. The pressure of miniaturization increased due to the huge success of miniaturized electromechanical integrated systems and a new branch of technology—Micro Electro—Mechanical Systems (or MEMS)—is emerging as a powerful entity for controlling the world economy. These are primarily lithography-based two-and-half-dimensional miniaturized devices. But the trend is already rearing its head which indicates the bright future for miniaturized machines and mechanisms also. And for the delight of members of the near-extinct community of kinematicians, the subject of mechanism synthesis has once again become important for applications in miniaturized machines and mechanisms. Using multiple-drive-based motion generation became infeasible and the technologists had to once again depend on synthesized mechanisms to generate the desired motion and trajectories as these became the only practical solutions. It can be safely stated that the rebirth of the subject 'kinematics and mechanism theory' has been possible because of the emergence of 'micromechanisms'.

Expectedly, the rebirth of the subject has brought along a number of fundamentally new concepts and paradigm shifts, which influence the basic configuration design, actuation, and fabrication. On many occasions engineers and technologists have started using principles from life science for the functioning of micromechanisms and microactuators. There are major changes from the point of view of the material used and the energy sources employed. Thus, it will be wrong to think that micromechanisms are just the miniaturized versions of their similar macroscopic counterparts.

As it happens with many new emerging branches of science and technology, in the emerging area of microsystems technology also, the subdivisions are not well-classified and considerable nebulosity exists in many definitions and characterizations. Because of continuous scaling down of microelectronic chips, industrial fabrication units started to become obsolete because of their limitations on size capability. These industrial units became useful for fabricating MEMS devices as, unlike microelectronic chips, these devices did not require a very high level of miniaturization. Since MEMS came directly as a product from the obsolete and abandoned microelectronic industry the growth of the subject has been fast and the expansion of its market very rapid. As a result, at present MEMS devices occupy a major part of the microsystems technology. The emergence of micromechanisms has been relatively slow because of their more involved fabrication process. Most often the subject 'microsystem' deals heavily with the discussions of MEMS technology. But it should be noted that the current area of microsystems, on the whole, consists of both MEMS devices (most of which are for sensing) and micromechanisms (which really perform the manipulation of material at the micro, nano, and molecular levels).

This introductory volume deals with primarily the active micro devices—micromechanisms—and the microactuators for driving the mechanisms. The design problems and concepts used in micromechanisms are substantially different from the traditional passive devices for sensing. It is hoped that this volume introducing the rudiments of micromechanisms and microactuators will be helpful to students of this subject and can be used to develop an introductory course.

Up till now, the development of the subject of micromechanisms has been somewhat disorganized in manner. A number of basic aspects are still in their infancy. Apart from this the R&D work on micromechanisms is mostly based on individual problems and specific systems. So, it is not always easy to identify a generalized discussion applicable to the whole class of these systems. In this introductory book, we attempt to identify the important aspects of miniaturization as it is expected to bring revolutionary changes in technology in the years to come. A separate chapter is included to discuss scaling laws as this topic is of utmost importance as far as miniaturization and microsystems are concerned. To make the volume self-contained, we have presented material on the general theory of mechanisms and techniques for synthesis of conventional mechanisms in the introductory chapters. Many micromechanisms are initially designed following the approaches adopted for their macroscopic counterparts. A general introduction to micromechanisms is given in a chapter preceding the chapter on their design. The chapter on design is followed by a chapter presenting some topics on the dynamics of micromechanisms.

The drive systems and actuators for micromechanisms are of extreme importance, as the impact of scaling effects is maximum on the actuation principles. Besides, there are many fundamentally new approaches for actuating micromechanisms. As it may have already become clear to many, when designing micromechanisms, a lot can be learned from the living world. Keeping this in view, similarity with biological systems has been pointed out in sections on design and structure of micromechanisms and microactuators. The chapter on microfabrication also discusses topics like 'self-assembly' that is closely related to life science.

Finally, the text presents the major fabrication techniques and the future possibilities.

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