

ANALYSIS OF MECHANISMS AND MACHINERY

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Preface

In the name of Allah, the Beneficent, the Merciful. All praise is to Him, the One. And peace be upon His messenger, the trust-worthy.

A course in kinematics of mechanisms, frequently followed by a second course in dynamics of machinery, has long been a fundamental item in mechanical engineering curricula. Such a course is based on the introductory courses of engineering mechanics (statics and dynamics), and is often the first of the professional courses in mechanical engineering. This book is intended to serve as a modern, computer-oriented text for this critical course.

The book provides more than enough material for a single-semester, junior-level course, allowing the instructor considerable freedom to select from among its topics. Parts of the book are also suitable for a beginning course at the graduate level. Because of the emphasis on analytical formulations and computer solutions, and the down-to-earth approach to the solution of practical engineering problems, this text will be of interest to practicing engineers as well.

The book begins in the name of Allah, the Mercy-giving, the Merciful. The initial chapter describes the viewpoint of treating the course material in a computer-oriented manner. The analysis of gear trains is considered in Chapter 2. Chapter 3 is concerned with the analytical design of cams. Chapters 4 to 7

are devoted to the study of linkages. Loop closure techniques as well as the dedicated software package, AL-YASEER, are introduced here. It is also here that the concept of a *virtual link* is introduced. Chapters 8 and 9 deal with special techniques of mechanism analysis, and with kinematically complex mechanisms.

Analysis of mechanisms and machinery under static and quasi-static loading conditions is addressed in Chapter 10. Chapters 11 and 12 are devoted to the investigation of machinery under dynamic conditions, where ample use is made of the power and facilities of AL-YASEER. Design of flywheels, as well as the investigation of gyroscopic and frictional effects are also treated in Chapter 12. Balancing is considered in Chapter 13. The book ends with a brief introduction to mechanical vibrations, and the discussion is augmented to cover the whirling of shafts. The appendices provide supplementary and review material on cams, the use of BASIC, as well as full documentation, figures, and flow charts pertaining to AL-YASEER. A *Quick Reference* utility is also provided as Appendix E.

From the very beginning, the book is thoroughly computer oriented. In view of global accreditation requirements for increasing the design content of mechanical engineering curricula, this book provides an excellent vehicle for studying mechanisms and machinery from the design perspective. The book also fits in with the emphasis, in engineering curricula, that is placed on computer aided engineering.

The student is encouraged to look at all problems - whether examples in the text or problems at the end of each chapter - from the standpoint of preparing them for a computer solution. In almost all cases the student is expected to actually carry the solution all the way through to a computer solution, and over a complete cycle of events. It is for the purpose of allowing the student to observe, and to appreciate the fluctuations in the variables of interest that take place during an entire cycle, that many answers are provided in the form of graphs, and not numbers. There are many cases where solution by computer is the only feasible avenue. On the other hand, the book accommodates many situations that can also be handled in closed form, without the aid of a computer.

Although computers have been available on university campuses for the last 30 years, the last decade has witnessed a profound revolution in computers. It is now a reality that every engineer has free access to a computer of some sort. Most of these machines, including many pocket and portable computers, possess the potential to solve the kind of problems encountered in the mechanics of machinery.

In terms of programming languages, virtually all PCs and microcomputers support some form of BASIC. Due to the universality of BASIC, the examples in this text are worked out in this language, although there is nothing about the methods of analysis that is tied to BASIC. Any of the methods presented here can be performed satisfactorily using any high-level programming language.

AL-YASEER, a user-friendly software package that was developed at KAU, is introduced and extensively used. To utilize AL-YASEER, the user partitions the mechanical system under consideration into its *basic linkages*. The basic linkages typically comprise the slider-crank mechanism and its inversions as well as the four-bar linkage. AL-YASEER contains, under separate subroutines, kinematic and dynamic relationships for each basic linkage. What is required from the user is the provision of dimensional, kinematic, and dynamic input data for the basic linkages. AL-YASEER then provides the totality of position, kinematic and force fields covering every joint as well as selected other points of interest in the mechanism assembly.

In the area of kinetics, the fundamental idea of working with *free body diagrams* is emphasized. Free use of AL-YASEER is subsequently made for undertaking dynamic force analyses of mechanical systems. It is demonstrated that the analysis of mechanisms and machinery becomes trivial in effort when AL-YASEER is utilized. The user has little more to provide than input and equivalency statements in order to have at his disposal a comprehensive analysis of the entire system. Computation for a complete cycle of events generally requires less than half an hour on portable/pocket computers. Perhaps the most significant aspect of this process is that the analysis is done in class, by the student himself, using his own pocket computer.

The student is introduced to BASIC in Chapter 3, where disk cams are addressed. The discussion on cams is approached first from the stand point of design. Several types of proven follower motions are discussed, using the computer as a training tool at this stage. Full details are provided in the Appendix, for the purpose of facilitating rough checks, on the graphical construction of cam profiles for follower motions and cam-follower configurations. The text itself dwells essentially on analytical design procedures developed for various cam configurations, making ample use of the computer.

The problems at the end of the chapters are plentiful, and are meant to be of a practical nature, relating directly to engineering practice. Many problems require cycle analyses to be undertaken, by the use of the computer, and some are provided with partial answers. Some figures are not to scale for clarity.

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May Allah enable us to accomplish what pleases Him. And He is the Knower of intentions.

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Mehmet Akyurt

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