Preface

The high cost and questionable supply of many materials, land and other resources, together with the sophisticated analysis and manufacturing methods now available, have resulted in the construction of many highly stressed and lightweight machines and structures, frequently with high energy sources, which have severe vibration problems. Often, these dynamic systems also operate under hostile environmental conditions and with minimum maintenance. It is to be expected that even higher performance levels will be demanded of all dynamic systems in the future, together with increasingly stringent performance requirement parameters such as low noise and vibration levels, ideal control system responses and low costs. In addition it is widely accepted that low vibration levels are necessary for the smooth and quiet running of machines, structures and all dynamic systems. This is a highly desirable and sought after feature which enhances any system and increases its perceived quality and value, so it is essential that the causes, effects and control of the vibration of engineering systems are clearly understood in order that effective analysis, design and modification may be carried out. That is, the demands made on many present day systems are so severe, that the analysis and assessment of the dynamic performance is now an essential and very important part of the design. Dynamic analysis is performed so that the system response to the expected excitation can be predicted and modifications made as required. This is necessary to control the dynamic response parameters such as vibration levels, stresses, fatigue, noise and resonance. It is also necessary to be able to analyse existing systems when considering the effects of modifications and searching for performance improvement.

There is therefore a great need for all practising designers, engineers and scientists, as well as students, to have a good understanding of the analysis methods used for predicting the vibration response of a system, and methods for determining control

system performance. It is also essential to be able to understand, and contribute to, published and quoted data in this field including the use of, and understanding of, computer programs.

There is great benefit to be gained by studying the analysis of vibrating systems and control system dynamics together, and in having this information in a single text, since the analyses of the vibration of elastic systems and the dynamics of control systems are closely linked. This is because in many cases the same equations of motion occur in the analysis of vibrating systems as in control systems, and thus the techniques and results developed in the analysis of one system may be applied to the other. It is therefore a very efficient way of studying vibration and control.

This has been successfully demonstrated in my previous books *Vibration Analysis and Control System Dynamics* (1981) and *Vibrations and Control Systems* (1988). Favourable reaction to these books and friendly encouragement from fellow academics, co-workers, students and my publisher has led me to write *Engineering Vibration Analysis with Application to Control Systems.*

Whilst I have adopted a similar approach in this book to that which I used previously, I have taken the opportunity to revise, modify, update and expand the material and the title reflects this. This new book discusses very comprehensively the analysis of the vibration of dynamic systems and then shows how the techniques and results obtained in vibration analysis may be applied to the study of control system dynamics. There are now 75 worked examples included, which amplify and demonstrate the analytical principles and techniques so that the text is at the same time more comprehensive and even easier to follow and understand than the earlier books. Furthermore, worked solutions and answers to most of the 130 or so problems set are included. (I trust that readers will try the problems *before* looking up the worked solutions in order to gain the greatest benefit from this.)

Excellent advanced specialised texts on engineering vibration analysis and control systems are available, and some are referred to in the text and in the bibliography, but they require advanced mathematical knowledge and understanding of dynamics, and often refer to idealised systems rather than to mathematical models of real systems. This book links basic dynamic analysis with these advanced texts, paying particular attention to the mathematical modelling and analysis of real systems and the interpretation of the results. It therefore gives an introduction to advanced and specialised analysis methods, and also describes how system parameters can be changed to achieve a desired dynamic performance.

The book is intended to give practising engineers, and scientists as well as students of engineering and science to first degree level, a thorough understanding of the principles and techniques involved in the analysis of vibrations and how they can also be applied to the analysis of control system dynamics. In addition it provides a sound theoretical basis for further study.

Chris Beards
January 1995