

## **PREFACE & ACKNOWLEDGEMENTS**

This book is the result of course notes developed for a graduate course on precision manufacturing at Berkeley and taught for the past decade or so. The course was developed to meet the growing need of mechanical engineers, and others, to understand the design and process issues associated with precision machine tools and the fabrication of precision components. It also tried to introduce some fundamental understanding of metrology and the techniques of measurement. These are big topics and we don't claim to cover all to sufficient depth in this book. But, the foundations laid here can be built upon for additional study.

The book is designed to compliment a typical 15 week semester course aimed at upper division and graduate level engineering students. The text is extensively referenced so that original sources can be consulted for more details if desired. At Berkeley, some industrial visits to local precision manufacturing firms and several laboratory exercises were included in the semester. These are not outlined in the book.

A substantial coverage of some of the historical events driving the development of manufacturing and machine tools is presented in Chapter 1. This is both fascinating as history as well as offers insight into why certain machines and processes are the way they are and the context in which they were developed. References to a number of excellent in depth histories of precision machines and instruments are given for more investigation.

This book is not so much an original creative product but the compilation, with insight, order, and some original material added of

course, of a large amount of existing material and expertise. The course notes and, ultimately, this book benefited from a great many contributors, experts in precision engineering worldwide and a special few who either lectured at Berkeley in the class, wrote books covering portions of the topics of interest here, or wrote technical papers published in journals and conference proceedings covering important aspects of precision manufacturing. The actual references are given in the text but a few have had a significant impact on the notes and should be mentioned.

A great number of excellent precision engineers have contributed to the book by their lectures, publications and conversations with the authors. Specifically, Professor Pat McKeown of Cranfield University, Professor Ichiro Inasaki of Keio University and Professor Hans-Kurt Tönshoff of the University of Hannover, and the late Professor Juri Tlusty, all spent time visiting Mechanical Engineering at Berkeley as Springer Professors. Their lectures and colloquia as part of their visits offered excellent material to set the tone for and contribute to several sections of this book. Two contributors, Mr. Jim Bryan, retired Chief Metrologist, and Dr. Ken Blaedel, retired precision engineer, both from Lawrence Livermore National Laboratory, lectured to the class, and, through contact at technical meetings and seminal publications in precision engineering, provided much material for the book. The chapter on thermal errors, for example, is based on Dr. Blaedel's short course notes on thermal errors and augmented with Mr. Bryan's technical publications.

Professor Alex Slocum of MIT wrote a first excellent book on Precision Machine Design which was used for the class for several years and serves as a competent reference. It is exceptionally detailed and covers the fundamentals of design of machines, fixtures, tooling and related elements. It does not cover manufacturing processes and, hence, this book was necessary. Similarly, Professor Bharat Bhushan of Ohio State University edited a handbook on nanotechnology that includes an impressive volume of information and detail on most aspects of nano-scale device design, processes and fundamentals. This book references both Slocum and Bhushan generously.

A group of very talented researchers and engineers in precision engineering and machine tool design, control and application contributed to a seven volume review of the state of the art of machine tool technology in the late 1970's. They represented national laboratories, industry and academia from around the world. Many of the same names listed above appear as authors of major sections of that study. Sponsored by the US Air Force and officially coordinated and published in 1980 by Lawrence Livermore National Laboratory (and, sadly, promptly forgotten by most folks it was designed to benefit in academia and industry), it provided a treasure trove of information on topics ranging from machine control to error budgets to sensor technology to business practices in the industry. You will see extensive reference to this amazing study in this book in several chapters.

One of the strings that binds the precision manufacturing community together is the International Academy for Production Engineering (CIRP). Many of the contributors mentioned above are Fellows of this Academy and numerous references to CIRP publications and presentations at the annual meetings provide critical material for this book. CIRP has played a leading role in precision manufacturing research and development for almost 60 years and the CIRP publications, presentations, and conversations of industry, academic, and national laboratory and institute participants in CIRP activities were a treasure trove of basic research and industrial application information.

Finally, many past student researchers, postdoctoral researchers, and visiting scholars to the Laboratory for Manufacturing and Sustainability in Mechanical Engineering at Berkeley have contributed to this book in various ways. You will see specific reference to their work throughout the chapters on sensors, process planning, precision machining processes, precision manufacturing applications and sustainable process design. And, in the laboratory, several engineering interns contributed more practically to the production of the book. A number of undergraduate students helped with preparation of images and figures over the years and one, Ms. Maddie Cousens,

lead the major effort to secure permissions for material used from other sources.

The assistance of all of these individuals and contributions are gratefully appreciated by the authors.

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