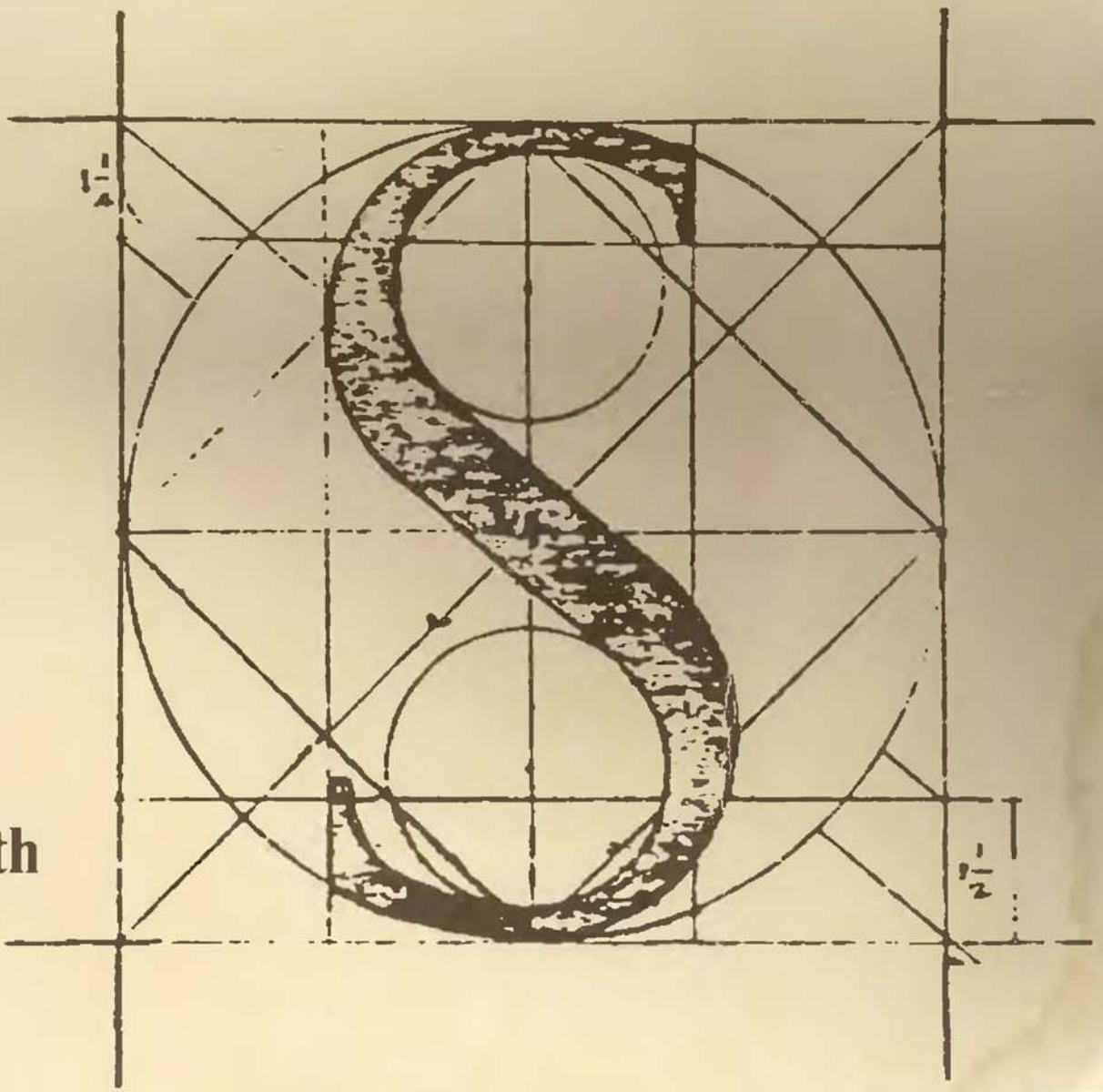
TEX and METAFONT

New Directions in Typesetting



Donald E. Knuth

TEX and METAFONT

New Directions in Typesetting

TEX and METAFONT

New Directions in Typesetting

Donald E. Knuth

digital

Digital Press

American Mathematical Society

TEX and METAFONT, New Directions in Typesetting is published jointly by the American Mathematical Society and Digital Press.

Printed in U.S.A.

1st Printing, December 1979
Documentation Number EY-BX003-DP-001

Knuth, Donald E
TEX and METAFONT, new directions in typesetting

Includes index.
1. Computerized typesetting. 1. Title.
Z253.3.K57 686.2'2544 79-25891
ISBN 0-932376-02-9

Cover illustration: the letter "S" as constructed by the Italian calligrapher Giovanbattista Palatino, circa 1550.

Foreword

Don Knuth's Tau Epsilon Chi (TEX) is potentially the most significant invention in typesetting in this century. It introduces a standard language for computer typography and in terms of importance could rank near the introduction of the Gutenberg press. The TEX system:

- understands typography from individual characters to page design;
- permits any typewriter, word processing system, computer-based editor, or TEX system editor to be used as an input device with a standard language;
- can typeset various formats and languages;
- is structured to be user-extendable to virtually all applications.

These improvements are benchmarks in typesetting and text creation. To date, computer-based typesetting systems have simply facilitated typesetting. Moreover, the proliferation of word processing systems makes possible the widespread direct transmission of text to typesetting without the intervening typesetting process—provided we use the standard language that TEX offers.

A direct link between text input and typesetting will permit a drastic restructuring of the journal- and book-publishing industry, allowing it to be oriented substantially more toward the author. Until now, even authors with word processing equipment have been unable to participate in the representation of their message in print. Prior to Gutenberg's invention, manuscripts were conceived and designed simultaneously, and often the author's hand shaped the entire final product. The results were beautiful and varied, in contrast to the manufacture of most modern books, which vary only in cover design. With TEX, moreover, not only can the author influence his own format and representation, but he also can produce more accurate material that can be rapidly mass-produced, shortening the time between idea and dissemination.

TEX is significant as a standard language because of the way it understands typography using a framework of boxes and glue in a hierarchical fashion so that any font, page layout, or other typesetting parameter can be set. This is in striking contrast to most typesetting systems, which are built

with no generality. Finally, the input form is user-defined by means of a macroprocessor so that virtually any text can be input and can control the typography part of the program. It is this generality and segmentation of function that makes TEX significant.

This book is about much more than just the TEX system. The Gibbs Lecture presents the twin themes of how typography can help mathematics and how mathematics can help typography, and the material on METAFONT is intriguing and useful in its description of the use of mathematics in type design.

While the emphasis of TEX is on mathematics, the system is equally applicable to and will no doubt be used in many other domains. Don Knuth, in fact, shows us precisely how the system can humanize basic communications.

At Digital, we hope to use TEX immediately. I urge others to adopt and use it so that the language standard can be established.

C. Gordon Bell
Vice President of Engineering
Digital Equipment Corporation

Preface

Leonardo da Vinci made a sweeping statement in his notebooks: "Let no one who is not a mathematician read my works." In fact, he said it twice, so he probably meant it.

Fortunately, a lot of people failed to heed his injunction. It turns out that non-mathematicians are quite capable of dealing with mathematical concepts, when the description isn't beclouded with too much jargon. So I would like to reverse Leonardo's dictum and say, "Let everyone who is not a mathematician read my works." (Furthermore, mathematicians are invited too.)

Of course, every author likes to be read; but I have quoted Leonardo as a sort of apology for the fact that the first part of this book is the text of a talk that was addressed specifically to professional mathematicians. Two years ago I was deeply honored by an invitation to give the 1978 Gibbs Lecture, a lecture about applied mathematics that is delivered annually to the members of the American Mathematical Society. Since such prominent mathematicians as G. H. Hardy, Albert Einstein, and John von Neumann had previously been Gibbs lecturers, I wanted to say something that wasn't completely trivial, so I threw in some mathematics that was at least slightly sophisticated. The main point I wished to make, however, was that mathematical ideas need not be confined to the traditional areas of application and that I had found it especially exciting to bring mathematics to bear on the field of typography. I hope some of my excitement and the reasons for it will be understood by everybody concerned with written communication and the making of books of high quality.

This book is in three parts, each of which is intended to be reasonably self-contained. First comes the Gibbs Lecture, which gives an overview of the typographic research I have been doing. Then comes a complete description of the TEX typesetting system, a new system that seems to incorporate the "right" fundamental principles for computer-based composition in its notions of horizontal and vertical lists of boxes and glue. The last part is a similar description of METAFONT, a system for device-independent design of character shapes. Since the three parts are independent, each has separate page numbers, and the TEX and METAFONT descriptions have separate indexes.

My research on typography began only in 1977, so I can't claim that TEX and METAFONT are the best solutions to the problems they deal with. All I can say is that they have been applied to a great variety of typographic

applications, and that the results look extremely promising. These initial successes have made it desirable to publish the present book as an interim report. In this way a larger community of people will be able to experiment with and criticize the ideas, even though TEX and METAFONT are in their infancy, and even though there hasn't yet been time for me to advance past the first draft of my designs for the fonts used or to typeset the material on a high-resolution phototypesetter.

I have been helped by so many people it is impossible to thank them all, so I must simply hit the highlights. In the first place, I want to thank the people at Digital Press for their encouragement to prepare this book and for the care with which they produced it. Second, I want to thank the American Mathematical Society for its unexpectedly strong endorsement of this work, and for the benefit of the experience and wisdom of several members of its editorial staff. Third, I wish to thank the National Science Foundation, the Office of Naval Research, and the IBM Corporation for supporting my research at Stanford. Fourth, I owe an enormous debt of gratitude to Leo Guibas and his associates at Xerox Research, who miraculously produced the camera-ready copy for Parts 2 and 3 of this book on experimental printing equipment. Fifth, I want to thank the hundreds of TEX users who have given me the benefit of their experiences. And above all, I wish to thank my wife, Jill, for her support and guidance.

D.E.K.
Stanford, California
August, 1979

Acknowledgments

D. E. Knuth: "Mathematical Typography." Copyright © 1979 by the American Mathematical Society. Reprinted with permission from the *Bulletin (New Series) of the American Mathematical Society*, March 1979, Vol. 1, No. 2, pp. 337–372. Josiah Willard Gibbs Lecture, given under the auspices of the American Mathematical Society, January 4, 1978; received by the editors February 10, 1978. This research was supported in part by the National Science Foundation grant MCS72-03752 A03, and by the Office of Naval Research contract N0014-76-C-0330.

D. E. Knuth: *TEX, a system for technical text.* Copyright © 1979 by the American Mathematical Society. Reprinted with permission. Originally published in June 1979 by the American Mathematical Society as a manual by the same title. The version that appears here is based on Stanford Artificial Intelligence Laboratory Memo AIM-317.3 / Computer Science Department Report No. STAN-CS-78-675, September 1979. This research was supported in part by the National Science Foundation grant MCS72-03752 A03, and by the Office of Naval Research contract N0014-76-C-0330. The author wishes to thank the many individuals who made helpful comments on the first drafts of the manual.

D. E. Knuth: *METAFONT, a system for alphabet design.* Copyright © 1979 by the American Mathematical Society. The version that appears here is based on Stanford Artificial Intelligence Laboratory Memo AIM-332 / Computer Science Department Report No. STAN-CS-79-762, September 1979. This research was supported in part by the National Science Foundation grant MCS72-03752 A03, and by the Office of Naval Research contract N0014-76-C-0330. The author wishes to thank the many individuals who made detailed comments on pre-preliminary drafts.

Digital Press gratefully acknowledges the support and cooperation of the American Mathematical Society.