Credits and acknowledgments for materials borrowed from other sources and reproduced, with permission, in this textbook appear on the appropriate page within text.

Copyright © 2020, 2015, 2010 by Pearson Education, Inc. 221 River Street, Hoboken, NJ 07030. All Rights Reserved. Manufactured in the United States of America. This publication is protected by copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise. For information regarding permissions, request forms, and the appropriate contacts within the Pearson Education Global Rights and Permissions department, please visit www.pearsoned.com/permissions/.

Acknowledgments of third-party content appear on the appropriate page within the text.

Unless otherwise indicated herein, any third-party trademarks, logos, or icons that may appear in this work are the property of their respective owners, and any references to third-party trademarks, logos, icons, or other trade dress are for demonstrative or descriptive purposes only. Such references are not intended to imply any sponsorship, endorsement, authorization, or promotion of Pearson’s products by the owners of such marks, or any relationship between the owner and Pearson Education, Inc., authors, licensees, or distributors.

Library of Congress Cataloging-in-Publication Data
Names: Kibbe, Richard R., author.
Classification: LCC TJ1185 .K458 2020 | DDC 621.9/02—dc23
LC record available at https://lccn.loc.gov/2018028023

ISBN 10: 0-13-489350-6
## Contents

Preface, vi  
Guided Tour, viii  
Acknowledgments, xi  
About the Authors, xiii

### SECTION A  
**Introduction, 1**  
**Unit 1** Careers and the Machinist’s Role in Process Plans, 3  
**Unit 2** Manufacturing Competitiveness and Improvement, 9  
**Unit 3** Shop Safety, 12  
**Unit 4** Threads and Fasteners, 19  
**Unit 5** Blueprint Reading Fundamentals, 30  
**Unit 6** Views and Line Types, 35  
**Unit 7** Dimensions, Tolerances, and Fits, 42  
**Unit 8** Fundamentals of GD&T, 48  
**Unit 9** Geometric Tolerancing, 51

### SECTION B  
**Hand Tools, 63**  
**Unit 1** Arbor and Shop Presses, 65  
**Unit 2** Work-Holding and Hand Tools, 72  
**Unit 3** Hacksaws, 79  
**Unit 4** Files, 82  
**Unit 5** Hand Reamers, 87  
**Unit 6** Identification and Use of Taps, 91  
**Unit 7** Tapping Procedures, 96  
**Unit 8** Thread-Cutting Dies and Their Uses, 101  
**Unit 9** Off-Hand Grinding, 105

### SECTION C  
**Dimensional Measurement, 109**  
**Unit 1** Measurement and Common Measuring Tools, 111  
**Unit 2** Systems of Measurement, 121  
**Unit 3** Using Steel Rules, 124  
**Unit 4** Using Vernier, Dial, and Digital Instruments for Direct Measurements, 133  
**Unit 5** Using Micrometers, 141  
**Unit 6** Using Comparison Measuring Instruments, 161  
**Unit 7** Using Gage Blocks, 177  
**Unit 8** Using Angular Measuring Instruments, 183  
**Unit 9** Quality in Manufacturing, 192  
**Unit 10** Statistics in Manufacturing, 201

### SECTION D  
**Materials, 213**  
**Unit 1** Selection and Identification of Steels, 216  
**Unit 2** Selection and Identification of Nonferrous Metals, 225  
**Unit 3** Hardening, Case Hardening, and Tempering, 231
## CONTENTS

### Unit 4
Annealing, Normalizing, and Stress Relieving, 243

### Unit 5
Rockwell and Brinell Hardness Testers, 246

---

### SECTION E
Layout, 255

- **Unit 1** Layout Tools, 257
- **Unit 2** Basic Semiprecision Layout Practice, 265
- **Unit 3** Basic Precision Layout Practice, 271

---

### SECTION F
Preparation for Machining Operations, 281

- **Unit 1** Machinability and Chip Formation, 283
- **Unit 2** Speeds and Feeds for Machine Tools, 291
- **Unit 3** Cutting Fluids, 298
- **Unit 4** Carbide Tooling Specification and Selection, 303

---

### SECTION G
Sawing Machines, 321

- **Unit 1** Types of Cutoff Machines and Safety, 323
- **Unit 2** Using Horizontal Cutoff Saws, 328
- **Unit 3** Preparing a Vertical Band Saw for Use, 334
- **Unit 4** Using a Vertical Band Saw, 340

---

### SECTION H
Drilling Machines, 347

- **Unit 1** Drill Press Fundamentals, 350
- **Unit 2** Drilling Tools, 353
- **Unit 3** Hand Grinding of Drills on the Pedestal Grinder, 360
- **Unit 4** Operating Drilling Machines, 364
- **Unit 5** Countersinking and Counterboring, 376
- **Unit 6** Reaming in the Drill Press, 379

---

### SECTION I
Turning Machines, 385

- **Unit 1** Engine Lathe Fundamentals, 390
- **Unit 2** Toolholders and Toolholding, 397
- **Unit 3** Cutting Tools for the Lathe, 403
- **Unit 4** Lathe Spindle Tooling, 410
- **Unit 5** Operating Lathe Controls, 416
- **Unit 6** Facing and Center Drilling, 419
- **Unit 7** Turning between Centers, 428
- **Unit 8** Alignment of Lathe Centers, 439
- **Unit 9** Other Lathe Operations, 442
- **Unit 10** Sixty-Degree Thread Information and Calculations, 454
- **Unit 11** Cutting Unified External Threads, 459
- **Unit 12** Cutting Unified Internal Threads, 469
- **Unit 13** Cutting Tapers, 473
- **Unit 14** Using Steady and Follower Rests, 483
- **Unit 15** Additional Thread Forms, 488
- **Unit 16** Cutting Acme Threads on the Lathe, 493

---

### SECTION J
Vertical Milling Machines, 497

- **Unit 1** Vertical Milling Machines, 499
- **Unit 2** Cutting Tools and Cutting Toolholders for the Vertical Milling Machine, 502
- **Unit 3** Setups on the Vertical Milling Machine, 511
- **Unit 4** Vertical Milling Machine Operations, 521
- **Unit 5** Using an Offset Boring Head, 531

---

### SECTION K
Horizontal Spindle Milling Machines, 535

- **Unit 1** Horizontal Spindle Milling Machines, 537
- **Unit 2** Types of Spindles, Arbors, and Adapters, 541
- **Unit 3** Arbor-Driven Milling Cutters, 544
**CONTENTS**

**Unit 4**  Work-Holding Methods and Standard Setups, 549  
**Unit 5**  Machine Setup and Plain Milling, 551  
**Unit 6**  Using Side Milling Cutters, 555

**SECTION L**  
Grinding and Abrasive Machining Processes, 559  
**Unit 1**  Types of Grinders, 561  
**Unit 2**  Selection and Use of Grinding Wheels, 565  
**Unit 3**  Setup of Surface Grinders, 574  
**Unit 4**  Using a Surface Grinder, 580  
**Unit 5**  Cylindrical Grinding, 586  
**Unit 6**  Using a Cylindrical Grinder, 590  
**Unit 7**  Universal Tool and Cutter Grinder, 594

**SECTION M**  
Computer Numerical Control and Other Advanced Machining Processes, 607  
**Unit 1**  Fundamentals of Computer Numerical Control (CNC), 608  
**Unit 2**  Fundamentals of Machining Centers, 616  
**Unit 3**  Fundamentals of Programming Machining Centers, 622  
**Unit 4**  Programming Examples, 637  
**Unit 5**  Programming Canned Cycles for Machining Centers, 646  
**Unit 6**  CNC Turning Machines, 656  
**Unit 7**  Programming CNC Turning Centers, 665  
**Unit 8**  Programming Canned Cycles for CNC Turning Centers, 678  
**Unit 9**  Advanced Machining Processes, 692

**APPENDIX 1**  
Answers to Self-Tests, 708

**APPENDIX 2**  
General Tables, 747  
**Table 1**  Decimal Equivalents of Fractional Inches, 748  
**Table 2**  Inch/Metric Conversion Table, 749  
**Table 3**  Tap Drill Sizes, 751  
**Table 4**  Metric Tap Drill Sizes, 752  
**Table 5A**  Tapers, 753  
**Table 5B**  Tapers and Angles, 754  
**Table 6**  General Measurements, 755  
**Table 7A**  Density or Specific Gravity of Metals and Alloys, 757  
**Table 7B**  Approximate Melting Points of Metals and Various Substances, 758  
**Table 8**  Right-Triangle Solution Formulas, 759  
**Table 9**  Wire Gages and Metric Equivalents, 760  
**Table 10**  Cutting Speeds for Commonly Used Materials, 761  
**Table 10A**  Feeds for High-Speed Steel End Mills, 761  
**Table 10B**  Coolants and Cutting Oils Used for General Machining, 761

**APPENDIX 3**  
Precision Vise Project Drawings, 762  
Glossary, 766  
Index, 775
As a definitive text in the field for more than 30 years, *Machine Tool Practices*, 11th edition, is geared toward successfully training machinists and tool & die makers about quality, blueprint reading, traditional machining processes, and CNC operation and programming. It is ideal for those enrolled in apprenticeship training, technical college programs, community college programs, and university courses. Presented in a student-friendly manner, the book lends itself well to classes that take a combined lecture/laboratory approach, as well as to a self-paced instructional environment.

**STRENGTHS AND UNIQUE SELLING POINTS**

With hundreds of color illustrations and well over a thousand color pictures, *Machine Tool Practices* is the best-illustrated book in this field. The text emphasizes practical shop knowledge and machine tool technology throughout and superbly illustrates the tools, equipment, and techniques that students will encounter in an industrial machine shop.

**CLASSICAL PRACTICE/CURRENT TRENDS**

Machine tools and machining practices have changed dramatically. This text has been aligned with standards that were developed by the National Institute of Metalworking Skills (NIMS). The National Institute for Metalworking Skills (NIMS) was formed in 1995 to develop and maintain a globally competitive American workforce. NIMS developed skills standards for industry, NIMS certifies individual skills against the standards and also accredits training programs that meet NIMS requirements. This text was developed for students studying machining who need to acquire the knowledge and skills required by industry and to obtain NIMS certifications, if they so desire.

*Machine Tool Practices* has the information that is essential for the reader to be effective in all areas of machining. With the solid background this text provides, readers will confidently understand and operate manual and CNC machines as well as other manufacturing processes.

**ORGANIZATION OF THE BOOK: TOTAL FLEXIBILITY TO SUIT YOUR TEACHING STYLE**

The book is divided into 13 major sections and provides total flexibility to suit your teaching style. Appendix 1 contains Answers to Self-Tests, Appendix 2 offers practical General Tables, and Appendix 3 showcases Precision Vise Project Drawings. For the student, this project embodies many set-ups and techniques used in general precision machine shop work. The text also contains a Glossary and an Index. Many units are designed around specific projects that provide performance experience for students. The book structure makes it easy for instructors to include additional projects that are applicable to their specific needs.

**NEW TO THIS EDITION**

This edition has been dramatically updated and improved to reflect changes in the machining field. The eleventh edition includes the following improvements:

- Vast improvements in the readability of the text to make it easier to read and understand.
- We have added coverage of several topics that graduates are sure to encounter in the workplace. Coverage of process plans and job packets (routings) has been added to help the student understand what they will encounter in the workplace. Practical coverage of ISO systems, calibration and the machinist’s role in them has also been added.
- Blueprint reading coverage has been completely re-written and expanded with additional coverage and extensive student questions and exercises. Geometric Dimensioning and Tolerancing (GD&T) has been added along with extensive questions and student exercises. We believe that there is enough coverage of
blueprint reading/GD&T that it could be the basis of a course if the instructor augments the material with additional worksheets, blueprints, and lecture to meet their individual needs. The supplements for this text, including the PowerPoints and the test bank, are additional materials that can be used for a BPR/GD&T class.

- CNC coverage has been completely rewritten and expanded. Coverage begins with the basics of CNC, then machining center programming followed by turning center programming. Coverage of canned cycles has been added for machining centers and turning centers. We believe that there is enough coverage in the CNC section that it could be the basis of a CNC course if the instructor augments the material with additional worksheets, blueprints, and lecture to meet their specific needs. The supplements for this text, including the PowerPoints and the test bank, provide additional materials that can be used for a CNC class.

- Speeds and feeds, carbide tooling, inserts and tool holders as well as their specification and selection have been dramatically expanded and improved.

- Extensive improvements in color photos and figures.

- Hundreds of color illustrations that ease comprehension and visually reinforce learning.

- Expanded self-test questions and exercises in each unit.

- A list of useful websites at the end of appropriate units that refer the reader to state-of-the-art information on cutting tools and machine shop equipment.
Introductory Overview
Introductions summarize and provide an overview of the main themes in each major section and help reinforce topics.

Objectives
Clearly stated objectives enable you to focus on what you should achieve by the end of each unit.

Photographs
Extensive use of color photographs provides you with views of actual machining operations.

Graphic Explanations
These detailed explanations highlight important concepts, common errors, and difficulties that machinists encounter.
Shop Tip

Shop Tip and Shop Tip–Craftsmanship boxes offer helpful tips and techniques to make the student a better and more intuitive machinist.

**SHOP TIP**

When reading any drawings in the machine shop, be sure to:

1. Read any and all notes on the drawing.
2. Be sure that you are using the latest revision of a drawing. Errors can occur by machining parts to older drawing revisions. If you are unsure about the revision, check with your supervisor or instructor.

New Technology

Directs students to the latest technology in the field.

**NEW TECHNOLOGY**

Twist drills ordinarily do not produce a smooth hole. Often, reamers are used to produce a more dimensionally accurate hole with a smoother bore. However, this process will not produce a finish smooth enough for all purposes. Burnishing drills are available, designed not only to drill the hole, but also to finish it to size and increase the hole quality. They can be used for production drilling of cast iron, die-cast aluminum, and other nonferrous materials. Burnishing drills are presently used in the automotive, aerospace, compressor, and computer parts industries.

Professional Practice

Professional Practice provides tips from professional work environments.

**PROFESSIONAL PRACTICE**

The way a worker maintains his or her hand tools reveals the kind of machinist he or she is. Dirty, greasy, or mishandled tools carelessly thrown into a drawer are difficult to find or use the next time around. After a hand tool is used, it should be wiped clean with a shop towel and stored neatly in the proper place. If the tool was drawn from a tool room, the attendant may not accept a dirty tool.

Safety First

Safety First boxes provide safety warnings related to handling and working with various pieces of equipment.

**SAFETY FIRST**

The primary danger in operating the vertical band machine is accidental contact with the cutting blade. Workpieces are often hand guided. One advantage in using the machines is that the pressure of the cut tends to hold the workpiece against the saw table. However, hands are often in close proximity to the blade. If you should contact the blade accidentally, an injury is almost sure to occur. You will not have time even to think about withdrawing your fingers before they are cut. Keep this in mind at all times when operating a band saw.

Always use a pusher against the workpiece whenever possible. This will keep your fingers away from the blade. Be careful when you are about to complete the cut. As the blade clears through the work, the pressure that you are applying is suddenly released, and your hand or finger can be carried into the blade. As you approach the end of the cut, reduce the feeding pressure as the blade cuts through.

Operating Tip

Advice on how to operate machinery students may come across in their studies or careers.

Self-Test

End-of-unit self-tests gauge how well you mastered the material.

**SELF-TEST**

1. What is the kerf?
2. What is the set on a saw blade?
3. What is the pitch of a hack saw blade?
4. What determines the selection of a saw blade for a job?
5. How hack saw blades fall into two basic categories. What are they?
6. What speed should be used in hand hack sawing?
7. Give four causes that make saw blades dull.
8. Give two reasons why hack saw blades break.
9. A new hack saw blade should not be used in a cut started with a blade that has been used. Why?
10. What dangers exist when a hack saw blade breaks while it is being used?

Internet References

The end of each unit lists pertinent Internet sites.

**INTERNET REFERENCES**

http://design-technology.info
COMPREHENSIVE TEACHING AND LEARNING PACKAGE

FOR THE INSTRUCTOR

Instructor’s Guide with Lesson Plans
This handy manual contains suggestions on how to use the text for both conventional and competency-based education. The manual has additional student exercises for the instructor to utilize as class assignments. It also includes unit post-tests and answer keys (ISBN–10: 0-13-498588-5).

Blueprint and GD&T Exercises
Worksheets and exercises are provided that can be used by an instructor to supplement a blueprint/GD&T course. Worksheets and exercises are provided that cover sketching views, sketching parts from views, identification of views, and blueprint reading and GD&T reading prints.

CNC
Worksheets, exercises and CNC projects are provided for machining centers and turning centers that can be used by an instructor to supplement a CNC course.

PowerPoint Presentations
PowerPoint presentations are designed to aide the instructor’s lecture on topics covered in the book (ISBN–10: 0-13-498580-X).

TestGen (Computerized Test Bank)
TestGen contains text-based questions in a format that enables instructors to select questions and create their own quizzes and tests (ISBN–10: 0-13-498587-7).

To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc, where you can register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail, including an instructor access code. Once you have received your code, log on to the site for full instructions on downloading the materials you wish to use.
The authors wholeheartedly thank the reviewers for the eleventh edition for their insight and feedback:

Larry Crain
West Kentucky Community & Technical College
Jason Dixon
Bakersfield College
Billy Graham
Northwest Technical Institute
Raymond A. Miller
University of Cincinnati
Samuel Obi
San Jose State University
John Shepherd
Mt. San Antonio College
Ed VanAvery
Mid Michigan Community College

The authors would also like to thank Chris Banyai-Riepl of OMAX Corporation for his major contribution to the content on waterjet technology.

The authors would also like to thank Sandra McLain of OMAX Corporation for her assistance.

The authors would like to thank the following companies and schools for their contributions:

The 600 Group Plc.
Aloris Tool Technology Co. Inc.
American Iron and Steel Institute
American Society of Mechanical Engineers
ArcelorMittal
ASM International®
ATTCO, Inc.
Barnes International, Inc.
Bazell Technologies
Besly Cutting Tools, Inc.
Bryant Grinder Corporation
Buck Chuck Company
California Community Colleges

Cinetic Landis Ltd.
Clausing Industrial, Inc.
Climax Portable Machine Tools, Inc.
CMPC Surface Finishes, Inc.
Cogsdill Tool Products, Inc.
Command Tooling Systems/EWS
Confederation College
Criterion Machine Works
Dake Corporation
Desmond-Stephan Manufacturing Company
DoALL Company
Enco Manufacturing Company
Engis Corporation
ERIX TOOL AB
Fadal Engineering
Fine Tools
Fox Valley Technical College
Haas Automation, Inc.
Hardinge Inc.
Harig Mfg. Corp.
HE&M Saw
Illinois Tool Works, Inc.
IMI Machine Tools Pvt. Ltd.
Ingersoll Cutting Tool
Kalamazoo Machine Tool
Kennametal, Inc.
K&M Industrial Machinery Co.
Lane Community College
Louis Levin & Son, Inc.
Lovejoy Tool Company, Inc.
MAG Giddings & Lewis, Inc.
MAG Industrial Automation Systems LLC
Magna-Lock USA, Inc.
ACKNOWLEDGMENTS

Mahr Federal Inc.
Maximum Advantage–Carolinas
Mazak Corp.
Metal Web News
Micro-Mark
Mitsubishi Laser
Mitutoyo America Corp.
Monarch Lathes
Monarch Machine Tool Company
North American Tool Corporation
Okamoto Corporation
Okuma America Corporation
Olson Saw Company
Pacific Machinery & Tool Steel Co.
Peerless Chain Company
Rank Scherr-Tumico, Inc.
Regal Cutting Tools
Reishauer Corp.
Reko Automation & Machine Tool
Renishaw, Inc.
Renishaw Plc
SCHUNK Inc.
Sii Megadiamond, Inc.
Sipco Machine Company
Southwestern Industries, Inc.
Supfina Machine Company, Inc.
TE-CO INC.
The duMONT Company, LLC
The L.S. Starrett Co.
TRUARC Company LLC
Ultramatic Equipment Co.
United Grinding Walter-EWAG
Vannattabros.com
Vermont Gage
Walker Magnetics
Weldon Tool–A Dauphin Precision Tool Brand
Wilson® Instruments
Wilton Corporation
Richard Kibbe (Late) served his apprenticeship in the shipbuilding industry and graduated as a journeyman marine machinist. He holds an associate in arts degree in applied arts from Yuba Community College with an emphasis in machine tool technology. He also holds bachelor’s and master’s degrees from the California State University with an emphasis in machine tool manufacturing technology.

Mr. Kibbe has considerable machine shop experience as well as community college and industrial teaching experience and is the author and co-author of several publications in the machine tool manufacturing field.

Roland Meyer spent the first 20 years of his career in the metal-working industry as a tool and die maker and machinist in machine design and manufacturing. He completed his apprenticeship as a tool and die maker at Siemens in Germany and then worked in die shops in Toronto and Windsor, Canada, before moving to Chicago, where he worked as a gage maker at Ford Motor Company. He was in charge of the U.S. Army machine shops in Korea and Italy for five years. When he returned to the United States, he worked in a manufacturing company designing and building experimental machines used in the timber and plywood industry.

He next entered academia and became the lead instructor at Lane Community College’s manufacturing technology program in Eugene, Oregon, where he taught for 25 years. As CNC became the new method in machining, he developed a CNC curriculum and program. When CAM became available, he also developed a state-of-the-art CAM program with the assistance of a local software company.

Jon Stenerson served an apprenticeship in Tool Making with Mercury Marine. He has a BBA from the University of Wisconsin-Oshkosh and a Masters Degree from the University of Wisconsin-Stout. He held certifications for Certified Quality Engineer, Certified Quality Auditor, and Certified Lead Auditor.

Jon is the author and co-author of several books in the machining and automation field. Jon spent many years teaching and developing self-paced machine tool and automation curriculum for Fox Valley Technical College.

Kelly Curran grew up in Michigan’s Upper Peninsula where he started working in machine shops at a very young age. He holds an Associate of Applied Science degree from Ferris State College with an emphasis in machine tool technology. He also holds an Associates of Applied Science degree from the Northern Michigan University with an emphasis in Business and a Bachelor of Science Degree in Career, Technical Education from University of Wisconsin Stout.

Mr. Curran has considerable machine shop experience as well as industrial teaching experience and is the author and co-author of several publications in the machine tool manufacturing field. Mr. Curran has spent many years developing self-paced machine tool curriculum for the State of Wisconsin and Fox Valley Technical College.

About the Authors