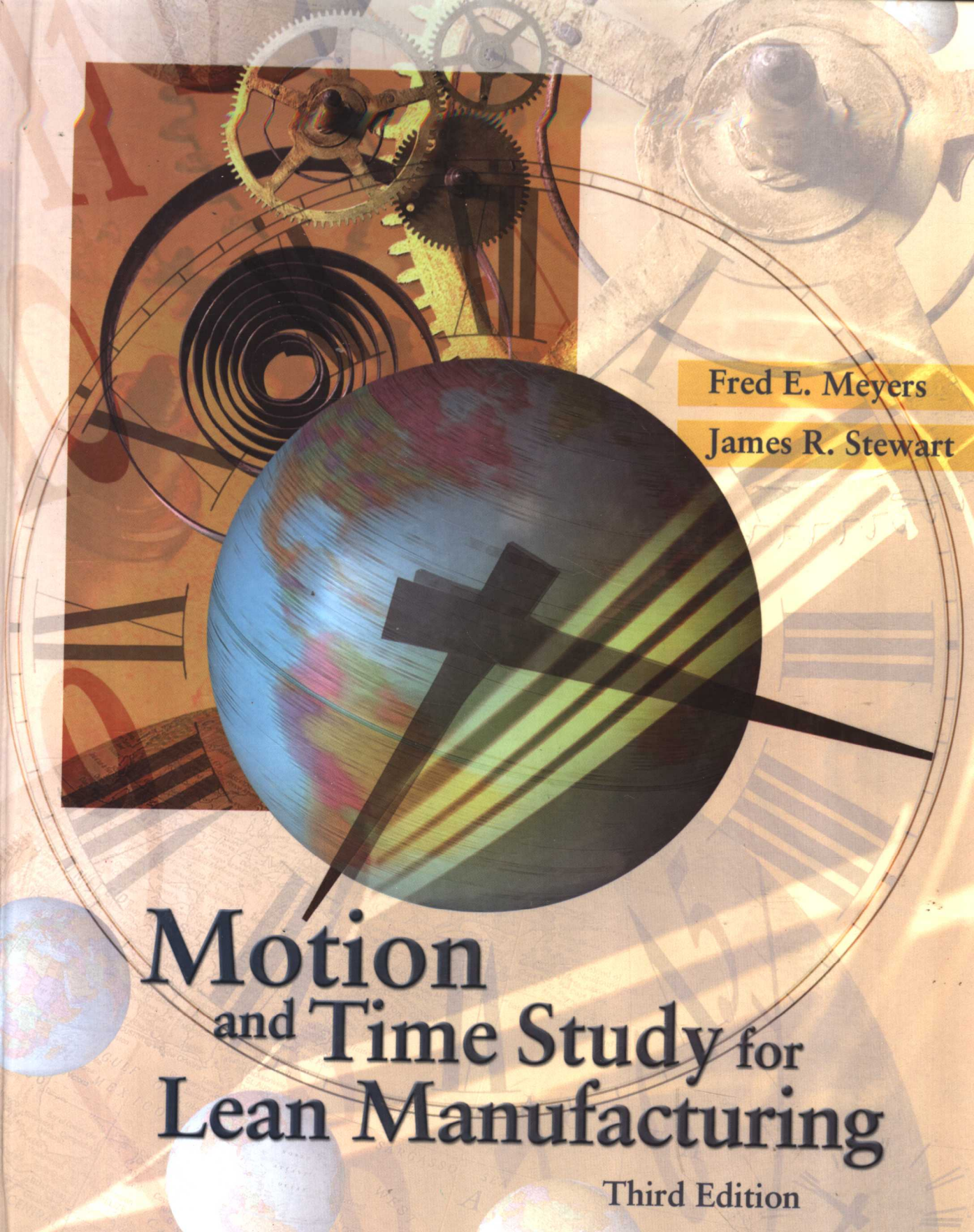

Fred E. Meyers
James R. Stewart

Motion and Time Study for Lean Manufacturing

Third Edition

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for Lean Manufacturing

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NORTHERN ILLINOIS UNIVERSITY

Prentice Hall

Upper Saddle River, New Jersey
Columbus, Ohio

Library of Congress Cataloging-in-Publication Data
Meyers, Fred E.
Motion and time study for lean manufacturing / Fred E. Meyers, James R. Stewart.—3rd ed.
p. cm.
ISBN 0-13-031670-9
1. Motion study. 2. Time study. 3. Methods engineering. I. Stewart, James R. (James Robert), II. Title
T60.7 .M48 2002
658.5'42—dc21 00-068468

Vice President and Editor in Chief: Stephen Helba
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Cover Art: © Visual Edge Imaging
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This book was set in Times Roman by The Clarinda Company and was printed and bound by R. R. Donnelley & Sons Company. The cover was printed by Phoenix Color Corp.

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada, Inc., *Toronto*
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Prentice-Hall of Japan, Inc., *Tokyo*
Prentice-Hall Singapore Pte. Ltd
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

10 9 8 7 6 5 4 3

ISBN: 0-13-031670-9

Preface

With the publication of the third edition, a new author, James R. Stewart, has been added to the team. Certainly this does not represent any change in the unique, down-to-earth teaching method of senior author and scholar Fred Meyers. Having been a user and supporter of this book since it was noted at a NAIT seminar a decade ago, the junior author intends to keep it as a text for the teaching of basic courses in using the tools of motion study and time study. Although the book has undergone a number of changes, it provides a practical education in the basic principles of motion and time study.

Over the past decade, lean manufacturing has become the philosophy for manufacturers who want to use the tools for improving operations. We see the concept as so important that a new Chapter 2 has been devoted to it. We describe it as a lean manufacturing environment. As an environment, it nurtures and supports many types of improvement systems and methods. And, it is open to the concepts of various cultures and methodologies. Because it sets the tone for all that follows, the chapter has been placed after the overview chapter and before the history chapter.

A number of persons important to work measurement have been added to the history chapter, Chapter 3. These include pioneers Henry Gantt and Harrington Emerson, early text authors, consultants, and educators Ralph Barnes and Marven Mundel, as well as Shigeo Shingo, the early Toyota pioneer of what is becoming the lean manufacturing environment. Although we considered many others, the lessons of the lives of these pioneers provide the guidance to install the lean manufacturing environment and to continue the innovation and improvement of our manufacturing system.

Chapter 4 has pulled together the introductory material scattered over several chapters. It now provides a concise but complete summary of what is to follow. Chapter 5 is directed toward teaching process charting and process improvement. Chapter 6 adds the SIMO chart to the other tools of operations analysis. Chapter 7 includes a new section on ergonomics and on the environmental aspects of the workplace. Predetermined Time Standards (PTS) Systems, Chapter 8, includes new descriptions of two commercial systems to the usable system that Fred Meyers designed. Time study has been left as developed in prior editions. Chapter 10 still includes the description of standard data but also has the calculation of line balancing and the concepts of lean manufacturing environment plant balancing. All of the material previously spread through three chapters is consolidated here. In Chapter 11, the principles of work sampling have been augmented by a new auditing procedure and form. A process for scheduling and measuring work performance supplements the indirect labor types described in Chapter 12. The last four chapters have been kept as written, as have the appendices.

References, sample problems, worked examples, tests, and other supplemental materials are published separately in the teacher's supplement. We hope students and teachers will find that the many changes in this edition add to their ability to learn and use the tools of motion and time study in the lean environment.

Acknowledgments

For the third edition, we wish to thank Rodha Balamuralikrishna for his figures. We also thank reviewers Kenneth Currie of Tennessee Technological University and Donna C. S. Summers, Ph. D., of the University of Dayton.

Fred E. Meyers
James R. Stewart

Preface to the Second Edition

The purpose of this how-to motion and time study book is to provide students and practitioners with a resource that describes the techniques and procedures of motion and time study. This book has appropriately been called a "cookbook." Practical, detailed advice is given on all aspects of motion and time study, including work station design, job analysis, and the techniques of setting time standards.

The mathematics requirement of this textbook is high school algebra. A few simple formulas are included in the standard data chapter. These formulas require the insertion of a variable to calculate the time requirement. Two more complicated formulas are used to show how tables are developed. The practitioner can use the tables to save time.

Motion study is accomplished before time standards are set. When a company decides to introduce a new product, a technician is asked to provide a plan to produce, for example, 1,500 units per day. The technician must design work stations for every fabrication, assembly, and packout operation. From the work station drawing, a left-hand/right-hand analysis of the work content is made. A predetermined time standard has been set for every body motion, so the times for every motion required to do the job are added together. This will be the time standard, and it was set before the company had the first part, machine, or operator.

Modern management requires constant vigilance of its industrial engineers and technicians to reduce costs, reduce effort, and improve the working environment. Lean manufacturing (the Toyota production system) has a word, *muda,* which means waste. More specifically, any activity that uses resources but does not add value is *muda.* Lean thinking is one solution to *muda.* Lean thinking promotes using less effort by

1. Eliminating useless motions,
2. Combining motions,
3. Changing the sequence of motions to make flow smoother, and
4. Simplifying motions.

Lean thinking results in the elimination or reduction of waste.

Motion and time study has finally found a home in the modern plant by helping employees to

1. Understand the nature and true costs of work,
2. Assist management in reducing unnecessary costs, and
3. Balance work cells to make work flow more smoothly.

Motion and time study has also contributed the concept of time standards, so that important management decisions can be made intelligently. Motion and time study can

1. Reduce and control costs,
2. Improve working conditions and environment, and
3. Motivate employees.

Manufacturing plant management needs time standards. Many major decisions would be only a guess without time standards. How would we determine how many machines to buy, how many people to hire, how much to sell the product for; how would we schedule the plant, how would we justify new methods or equipment, how would we ensure a balanced work load on assembly lines, and how would we evaluate employees or pay for increased effort? Chapter 4 answers these questions and inspires an appreciation of the importance of motion and time study.

This book will equip engineers and managers with the purposes, attitudes, methods, and techniques of motion and time study to make their plants leaner. Chapters 5 through 8 discuss methods analysis techniques.

Stopwatch time study can be accomplished only after the machines have been installed and the operators fully trained. In a proposed new plant, no machines or employees are available to time study, but an operating plant can use stopwatch time study very effectively. The stopwatch technique is the oldest technique of setting time standards and it is entrenched in many companies. Chapter 9 examines this technique.

Standard data is another technique of setting time standards before production begins, but it is developed from in-plant experience. Standard data is very personal to a specific company, and companies cannot normally use another's standard data. This is the most accurate, least costly method of setting time standards, and every motion and time study department should be developing its own. Chapter 10 examines this technique.

Work sampling is based on the laws of probability and it is a scientific technique of setting quality time standards. Office work, engineering departments, maintenance craft, and even equipment can be work sampled. Everyone who has worked with others has work sampled. Chapter 11 discusses this common practice in a scientific light. Consultants often use work sampling first to establish the beginning efficiency of the operation. Potential savings forecasts will be based on current efficiency.

Labor is a significant portion of manufacturing cost and must be controlled. Performance control systems based on time standards give management the control they need. History and research have shown that operations working without a performance control system average 60% of normal. When a performance control system is established, 85% performance results. Industrial plants on incentive average 120% performance. The size of these cost reductions is spectacular, and no industrial engineer, technologist, or manager will go unnoticed when such improvements are made. Chapter 13 discusses performance control systems.

Chapter 12 discusses uses of time standards that could be an important part of a technologist's career. Wage payment (Chapter 14) includes incentive systems, which is a fun area in which technologists can work. Assembly line balancing (Chapter 10) includes instructions on setting up assembly lines. This is a big area in many plants.

Most of the textbook deals with direct factory labor, but every area of business can be positively influenced by motion and time study. Chapter 12 discusses 10 of the largest indirect labor categories.

Chapter 15, the time management techniques chapter, is aimed at making the motion and time study technologist more productive.

Human relationships are an important part of motion and time study. The successful attitudes and goals of motion and time study technologists are discussed in Chapter 16.

A step-by-step procedure, real-life examples, sample problems, and blank forms are included for every technique. This book will remain a good reference years after a course or seminar on motion and time study.

Your feedback will be valued and considered for future editions. You may write to me in care of Prentice Hall, One Lake Street, Upper Saddle River, New Jersey 07458. Our objective is to provide a practical, usable, how-to text for motion and time study.

Acknowledgments

I am a student of Ralph Barnes, Peter August, and Mitchell Fein. All three have influenced me greatly, and their attitudes are part of me. I must thank Dr. Matthew P. Stevens, of Purdue University, for his statistical expertise and help, and Dr. Richard Edwards, of the University of Kentucky, for his continuing support and encouragement.

I also thank the reviewers of the second edition for their helpful comments: S. Deivanayagam, Tennessee Technical University; Alfred R. Hamelin, Walters State Community College; Matthew R. Meyer, Asheville-Buncombe Technical College; and Ross Udey, Peru State College.

Fred E. Meyers

About the Authors

Fred E. Meyers is president of Fred Meyers and Associates, an industrial engineering management consulting company. He designs and implements production improvement and motivation systems. Mr. Meyers is a registered professional industrial engineer and a senior member of the Institute of Industrial Engineers. He has 35 years of industrial engineering experience. He has worked for Caterpillar Tractor Co., Boeing's aerospace division, Mattel Toy Co., Times Mirror Corp., Ingersoll-Rand's proto tool division, Spaulding's golf club division, and Southern Illinois University–Carbondale, College of Engineering, where he taught for 20 years while starting and operating his consulting business. He was director of applied research and an associate professor.

Mr. Meyers has worked for over 100 companies as a consultant responsible for installing incentive systems, performance control systems, plant layouts, new product startup, and cost estimating systems. He has worked in heavy equipment manufacturing, aerospace, consumer products, appliance manufacturing, lumber, plywood, paper, oil blending and packaging, furniture, tooling, fiberglass, and many other areas. The variety of his assignments has given him the ability to see the wide-ranging uses of motion and time study.

Fred E. Meyers has taught motion and time study to over 130 classes and 5,000 people, including professional engineers and managers, union stewards, and college students. He has presented seminars to the National Association of Industrial Technology, industrial plants, the U.S. Air Force and Navy, and labor unions.

James R. Stewart is Associate Professor of Technology at Northern Illinois University. For the past decade, he has taught plant layout, engineering economy, manufacturing philosophy, production and inventory systems, industrial quality control, ergonomics, and work measurement and improvement. He is a Fellow in the World Academy of Productivity Science. He is a senior member of the Institute of Industrial Engineers and is a founding member and is on the board of directors of the Society for Work Science. He is also on the board of The International MODAPTS Association. He is an active member of a number of other societies, including NAIT, ASQ, and Human Factors and Ergonomics Society. He has 30 years of experience in work measurement in education, government, and industry.

Dr. Stewart has served on the faculty of several universities; worked in city, county and state productivity programs; and has managed engineering programs in electronics assembly, electronics component fabrication, pulp and paper fabrication, fiberglass processing, industrial tape manufacturing, and engineering consulting. He has published many articles about unique applications of work measurement. James R. Stewart has taught motion and time study in credit and noncredit courses for over 25 years. He has been certified and taught a number of predetermined time systems, including MOST, Work Factor, MTM-1, and MODAPTS.

Contents

CHAPTER 1

Introduction to Motion and Time Study

A new vocabulary has developed in the past decade that stems from the Toyota production system and a book titled *Lean Thinking* by James Womack and Daniel Jones. Lean manufacturing is a concept whereby all production people work together to eliminate waste. Industrial engineering, industrial technologists, and other groups within management have been attempting this by themselves since the beginning of the Industrial Revolution, but now that we have a well-educated, motivated production work force, modern manufacturing management has discovered the advantage of seeking the work force's help in eliminating waste. The Japanese have a word for waste, *muda,* which is the focus of much attention all over the world. Who knows better than the production employee, who spends eight hours a day on a job, how to reduce waste? The goal is to tap this resource by giving production employees the best tools available, and the techniques within a motion and time study course are some of the tools they need to do their new job.

Applications of lean manufacturing have begun to appear in American industry. These have been documented in a book called *Becoming Lean: Inside Stories of U.S. Manufacturers,* edited by Jeffrey Liker, which describes the process and problems of installing and maintaining lean manufacturing. However, much of the force behind the lean manufacturing environment is attributable to Shigeo Shingo and his landmark work in industrial engineering at Toyota. Firmly based on the works of the pioneers of motion study and methods improvement, he has provided a challenge to improve our methods, our operations, and our systems. Indeed, systems do not have to be confined to the walls of a plant nor of a company—the entire response to the needs of an individual can be improved: cross-cutural, cross-national, cross-company, one efficient system for the manufacture of goods and services,

all designed, manufactured, and delivered in the lean environment. All utilizing—no, all requiring—the tools and approaches presented in this book.

Motion and time study helps employees understand the nature and true costs of work, and it helps them assist management in reducing unnecessary costs and balancing work cells to make work flow smoother. In addition, time standards help managers make important management decisions intelligently. For example, manufacturing plant management needs time standards, even before production starts, to determine how many people to hire, how many machines to buy, how fast to move conveyors, how to divide work among employees, and how much the product will cost; and, after production starts, to determine how much cost reductions will return, who works the hardest, and perhaps who should earn more money. Motion and time study can reduce and control costs, improve working conditions and environment, and motivate people. This book will equip engineers, technologists, and managers with the purposes, attitudes, methods, and techniques of motion and time study to make plants leaner and, in turn, to train the work force in the techniques of motion and time study.

Upon completion of a course in motion and time study, you will have an appreciation of the techniques that measure and control costs, the confidence to apply them to your organization, and a desire to involve all employees in your company's cost reduction and cost control efforts.

Motion and time study is purely the study of techniques. There are about 25 techniques that assist in the study and measurement of work, and these techniques are the main subject of this text. These techniques are constantly improving, but their basic purpose is to improve the world of work and to reduce *muda* (waste). This book examines the techniques in the following general categories:

1. Motion analysis techniques
2. Time study techniques
3. Uses of time standards.

Manufacturing management and engineering students are being prepared to design work stations, develop efficient and effective work methods, establish time standards, balance assembly lines, estimate labor costs, develop effective tooling, select proper equipment, and lay out manufacturing facilities. However, the most important thing to learn is how to train production workers in these skills and techniques so they can become motion and time conscious.

A person working with motion and time study will study an individual job or series of jobs to learn the details of that work and make changes. Changes may be small, but improvements must be made continually to keep the company competitive. Without change, no growth occurs and failure is imminent. A company must never stop looking for improvements or it will become obsolete. A company that can involve all its employees in this effort toward improvement will have a competitive advantage that will lead to a larger market share.

Very few industries have new technology that is exclusively theirs. However, industries have something that is more important than exclusive technology: employees who understand that improvement comes only by hard work and attention to detail. There is no easy way.

Breaking down a job into its smallest components and putting it back together again using motion study techniques will result in an improvement. A motion and time study person will have the following attitudes:

"We can reduce the cost of any job."

"Cost is our measuring rod."

"Cost reduction is our job."

American industry must continue to deliver quality products at a reasonable price. Quality and price are the most important considerations for staying competitive. Motion and time study people concentrate on reducing costs but must never lose sight of quality. The following attitudes are critical:

"We never propose a method that will reduce quality."

"We never set standards for producing scrap."

"Lower cost and high quality are our competitive edge. One without the other leads to failure."

"Work smarter, not harder" has been the motto of every industrial engineer, manager, and technologist, but the new motto should be "Work smarter *and* harder."

Motion study offers a great potential for savings in any area of human effort. We can save the total cost of an element of work by *eliminating* it. We can greatly reduce the cost by *combining* elements of one task with elements of another task. We can *rearrange* the elements of a task to make it easier. We can also *simplify* the task by moving parts and tools close to the point of use, or pre-positioning parts and tools, or providing mechanical assists, or downgrading elements of work to less time-consuming elements; and we can even have the part redesigned to make it easier to produce. Simplification is the most time-consuming way of reducing costs, and its savings are small compared to eliminating or combining elements, but we can always simplify. These subjects and techniques are called work simplification or the cost reduction formula, and we will discuss them in great detail (see Chapters 5 through 8).

Motion study uses the principles of motion economy to develop work stations that are friendly to the human body and efficient in their operation. The field of ergonomics studies the effect of motions on the human body and has become an extremely important part of developing work methods. Ergonomics is a complex subject and should be a course or even a field of study of its own. This textbook cannot do it justice and still cover all the other areas of motion and time study, but people who want to make motion and time study, job design, or any other area of manufacturing management or engineering their chosen career field should take as many courses in ergonomics as are offered. This text will study the principles of motion economy, which just touches the surface of the larger field of ergonomics. People who design work stations must be aware of the impact their designs will have on people's lives. The designers can make work harder than it needs to be if they do not pay attention to the principles of motion economy and the field of ergonomics.