MANUFACTURING PROCESSES & SYSTEMS

NINTH EDITION

MANUFACTURING PROCESSES AND SYSTEMS

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Approximate Conversion Factors

From English Unit	To SI Unit	Multiply by
Acceleration		
foot per second squared	meter per second squared (m/s^2)	3.048×10^{-1}
inch per second squared	meter per second squared (m/s^2)	2.540×10^{-2}
Area		
square foot	square meter (m^2)	9.290×10^{-2}
square inch	square meter (m^2)	6.451×10^{-4}
Energy		
BTU	joule (J)	1.055×10^{3}
foot-poundal	joule (J)	4.214×10^{-2}
foot pound-force	joule (J)	1.355
kilowatt-hour	joule (J)	3.600×10^{6}
Force		
ounce-force	newton (N)	2.780×10^{-1}
poundal	newton (N)	1.382×10^{-1}
pound-force	newton (N)	4.448
Length		
foot	meter (m)	3.048×10^{-1}
inch	millimeter (mm)	2.540×10^{1}
mile	kilometer (km)	1.609
Mass		
ounce (avoirdupois)	kilogram (kg)	2.834×10^{-2}
ounce (troy)	kilogram (kg)	3.110×10^{-2}
pound (avoirdupois)	kilogram (kg)	4.535×10^{-1}
Power		
BTU per hour	watt (W)	2.930×10^{-1}
horsepower (electric)	watt (W)	7.460×10^{2}
horsepower (550 foot pound-force per second)	watt (W)	7.456×10^{2}
Pressure		
pound-force per square inch (psi)	pascal (Pa)	6.894×10^{3}
torr	pascal (Pa)	1.333×10^{2}
Temperature		
degree Fahrenheit	degree Celsius (C)	$(t_f - 32)/1.8$
Torque		
ounce-force inch	newton meter (Nm)	7.061×10^{-3}
pound-force foot	newton meter (Nm)	1.355
Velocity		
foot per min	meter per second (m/s)	5.080×10^{-3}
mile per hour	meter per second (m/s)	4.470×10^{-1}
mile per hour	kilometer per hour (k/h)	1.609
Volume		
cubic foot	cubic meter (m^3)	2.831×10^{-2}
cubic inch	cubic meter (m^3)	1.638×10^{-5}
gallon (U.S. liquid)	cubic meter (m^3)	3.785×10^{-3}
quart (U.S. liquid)	litre (l)	9.463×10^{-4}

Units Used in the SI System

Quantity	Unit	Symbol	Formula
Base Unit			
Length	meter	m	
Mass	kilogram	kg	
Time	second	s	
Electric current	ampere	A	
Thermodynamic temperature	kelvin	K	
Amount of substance	mole	mol	
Luminous intensity	candela	cd	
Supplementary Units			
Plane angle	radian	rad	
Solid angle	steradian	sr	
Derived Units			
Acceleration	meter per second squared		m/s^2
Angular acceleration	radian per second squared		rad/s^2
Angular velocity	radian per second		rad/s
Area	square meter		m^2
Density	kilogram per cubic meter		kg/m^3
Electric capacitance	farad	F	$A \cdot s/V$
Electric inductance	henry	H	$V \cdot s/A$
Electric potential difference	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Electromotive force	volt	V	W/A
Energy	joule	J	$N \cdot m$
Entropy	joule per kelvin		J/K
Force	newton	N	$kg \cdot m/s^2$
Frequency	hertz	Hz	cps
Luminous flux	lumen	lm	$cd \cdot sr$
Magnetic flux	weber	Wb	$V \cdot s$
Magnetomotive force	ampere	A	
Power	watt	W	J/s
Pressure	pascal	Pa	N/m^2
Quantity of electricity	coulomb	C	$A \cdot s$
Quantity of heat	joule	J	$N \cdot m$
Specific heat	joule per kilogram-kelvin		$J/kg \cdot K$
Stress	pascal	Pa	N/m^2
Thermal conductivity	watt per meter-kelvin		$W/m \cdot K$
Velocity	meter per second		m/s
Voltage	volt	V	W/A
Volume	cubic meter		m^3
Weight (force)	newton	N	$kg \cdot m/s^2$
Work	joule	J	$N \cdot m$

MANUFACTURING PROCESSES AND SYSTEMS

PREFACE

The business of manufacturing is no longer a "processes only" activity. Traditionally, manufacturing processes had a limited perspective of dealing with transformation of material. Manufacturing leaders now proclaim that the process is *no more or no less* important than the system. For manufacturing to excel, it must include dramatic improvements in *systems.* In acknowledging this new reality, we have changed the name of the book Manufacturing Processes to *Manufacturing Processes and Systems* for the ninth edition.

Student learning and instructor teaching are two different sides of the coin. Figure P.1 shows how our gears of manufacturing learning and teaching works. Processes and support systems can only abide in this new world of manufacturing, and the instructor is the key to this paradigm.

In this edition, the instructor will notice several new chapters: Electronic Fabrication (Chapter 19), Operations Planning (Chapter 23), Quality Systems (Chapter 27), Process Automation (Chapter 29), Operator-Machine Systems (Chapter 30), and Cost Estimating (Chapter 31). These chapters focus on the systems side of manufacturing. Throughout the book, much more stress is given to this aspect of manufacturing. Integration is now the means to successful practice. Learning about systems is essential to manufacturing education, and the field is incomplete without it.

With increasing emphasis of design over manual skills in modern manufacturing courses, the text is introducing chapters on The Manufacturing System (Chapter 1), Geometric Dimensioning and Tolerancing (Chapter 24), Tool Design (Chapter 25), and Quality Systems (Chapter 27). This integration is coupled to the processes/systems context of manufacturing.

This text can be used for a variety of teaching situations: for lecture only, for lecture with a laboratory menu, or with professional mentoring with business, and developed field trips. A companion use of video and television learning through the lecture mode is possible. The instructor will notice Internet requirements that search for information. We provide Internet addresses throughout the book for various assignments. (Regrettably, these addresses may change from time to time.) In the interactive environment of teaching, this book is a part of modern courseware.

The instructor also will appreciate the versatility of this book. The book has more material than can be covered in one semester or quarter, and thus independent chapters can be selected to meet the various objectives of each class. For example, if the students already have an understanding of materials, Chapter 2, Nature and Properties of Materials, can be excluded from the course curriculum. Other chapters also can be excluded depending on student preparation and course objectives. However, there is enough material to cover two semesters or three quarters, if a longer teaching opportunity is available.

Some colleges or universities will use the book with a laboratory, which can be coordinated with the chapter selection. Other colleges or universities that simultaneously employ video or television assistance may adopt the book to give academic content to the instruction.

Practicing professionals, who have climbed from the ranks in industry, will find this

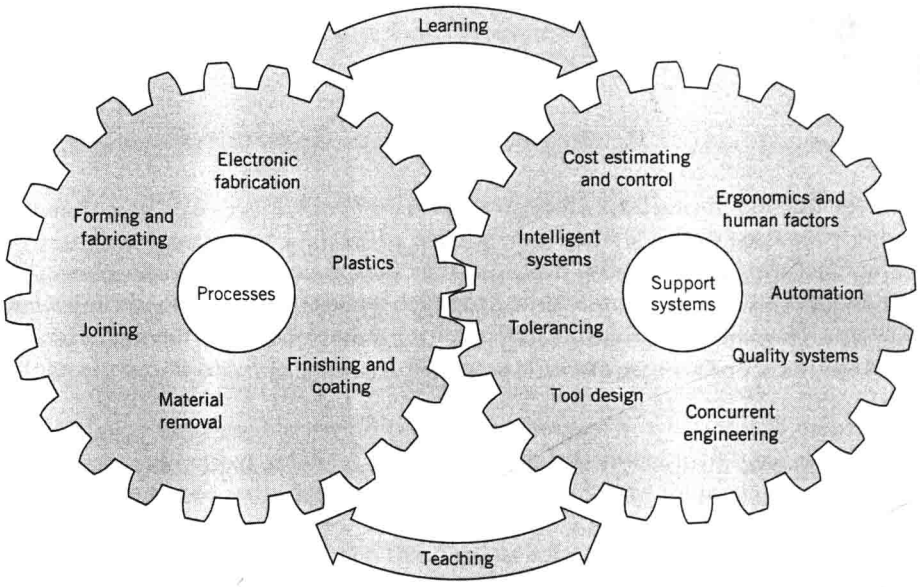

Figure P.1
Gears of learning and teaching for the manufacturing enterprise.

text useful for self-study. Even the apprentice needs a companion, and this text is a friend to many motivated young people. Many companies that provide in-plant courses to their employees also will see a need for this text.

The ninth edition has an increased number of Questions, Problems, More Difficult Problems, Practical Applications, and Case Studies. There is a range of difficulty for Questions. Some only require looking back in the chapter and responding with a few sentences. Other Questions seek a more thoughtful response. The Problems also have levels of difficulty. We stress manufacturing as a design activity; therefore, Problems and More Difficult Problems request sketches, CAD drawings, or computations. The student can provide this design using CAD, board and T-square, or sketches. Whenever the student is asked to prepare designs, much learning occurs.

For the instructor, a comprehensive Solution's Manual is available. This manual can be requested from the John Wiley college representative or from John Wiley and Sons directly.

There is a new end-of-chapter addition for the ninth edition, which we call Practical Applications. For example, it encourages field trips and communication through the Internet to technologists, engineers, and other manufacturing professionals. It asks for observations of ongoing operations, of operation of equipment to make parts, of visiting machine tool shows, and so on. The instructor will appreciate this experiential approach, allowing him or her to use Practical Applications in exciting ways.

The end-of-chapter Case Studies are open ended, perhaps having several solutions. Students are often disturbed by this anomaly, but instructors recognize that manufacturing courses are unlike calculus courses with their singularity of answers.

Academic requirements for this book/course can vary, but we believe that the text is widely suitable for a number of teaching approaches. The book has been written to appeal to a range of college/university/technical school settings. The student need only

have a mathematics level of algebra and a high school or college courses in chemistry and physics. Word-processing computer skills are assumed, and some CAD ability is always helpful. A previous machine shop course is not necessary, nor is a concurrent laboratory course mandatory. Various academic levels and backgrounds are appropriate and the instructor will find that this text is suitable to a variety of teaching styles.

We have added information on the latest technology, keeping this text current with the rapidly changing field of manufacturing. For example, chapters on Electronic Fabrication (Chapter 19), Finish Processes (Chapter 22), Metrology and Testing (Chapter 26), and Computer Numerical Control Systems (Chapter 28) have been added or strengthened. When one realizes that electronic fabrication is an annual trillion dollar business, it is folly to ignore this pivotal manufacturing field of study. The book has been thoroughly rewritten, and now encourages the *design* pedagogy of learning.

The ninth edition of *Manufacturing Processes and Systems* is the longest running active book in this field. There are many international translations. If this book is considered exemplary, it is due to the late Professor Myron Begeman, who was the original author. He added Professor B.H. Amstead, now retired, and Bill's imprimatur is unmistakable and vitally important to the current authors. For the seventh and eighth editions, Professor Phillip F. Ostwald contributed as a co-author. Now with the ninth edition, a new co-author is continuing the book's grand heritage, Dr. Jairo Muñoz. He brings real-world experience as a practicing professional manufacturing engineer/manager/researcher to this book.

The authors are grateful to many people. Their advice and information has made this a much better text. Our special gratitude is given to helpful people such as William W. Wainwright, the late Franklin Essenburg, Chung ha Suh, Sander Friedman, Thomas Carson, Gordon Nordyke, Steve Hirsch, and Bill Kennedy. Students have graciously consented to field test the problems and have assisted in numerous other ways. The names used in the case studies are of real people, and they are mentioned because of our sincere regard for their contribution and friendship. For in writing a book of this magnitude, the authors are always aware that friends and colleagues are the hidden but important advisers.

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