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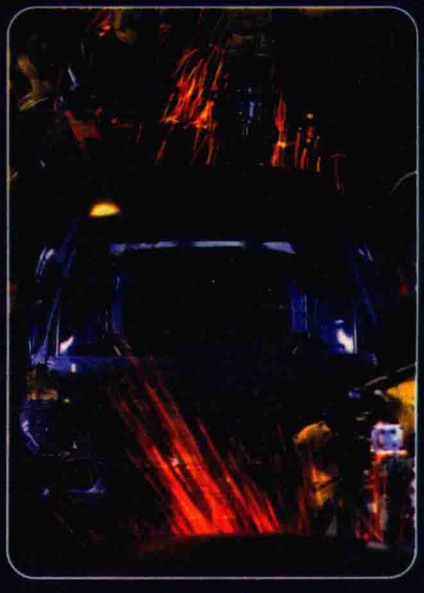

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机械工业出版社
China Machine Press

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出版者的话

文艺复兴以降，源远流长的科学精神和逐步形成的学术规范，使西方国家在自然科学的各个领域取得了垄断性的优势；也正是这样的传统，使美国在信息技术发展的六十多年间名家辈出、独领风骚。在商业化的进程中，美国的产业界与教育界越来越紧密地结合，计算机学科中的许多泰山北斗同时身处科研和教学的最前线，由此而产生的经典科学著作，不仅擘划了研究的范畴，还揭橥了学术的源变，既遵循学术规范，又自有学者个性，其价值并不会因年月的流逝而减退。

近年，在全球信息化大潮的推动下，我国的计算机产业发展迅猛，对专业人才的需求日益迫切。这对计算机教育界和出版界都既是机遇，也是挑战；而专业教材的建设在教育战略上显得举足轻重。在我国信息技术发展时间较短、从业人员较少的现状下，美国等发达国家在其计算机科学发展的几十年间积淀的经典教材仍有许多值得借鉴之处。因此，引进一批国外优秀计算机教材将对我国计算机教育事业的发展起积极的推动作用，也是与世界接轨、建设真正的世界一流大学的必由之路。

机械工业出版社华章图文信息有限公司较早意识到“出版要为教育服务”。自1998年开始，华章公司就将工作重点放在了遴选、移译国外优秀教材上。经过几年的不懈努力，我们与Prentice Hall，Addison-Wesley，McGraw-Hill，Morgan Kaufmann等世界著名出版公司建立了良好的合作关系，从它们现有的数百种教材中甄选出Tanenbaum，Stroustrup，Kernighan，Jim Gray等大师名家的一批经典作品，以“计算机科学丛书”为总称出版，供读者学习、研究及度藏。大理石纹理的封面，也正体现了这套丛书的品位和格调。

“计算机科学丛书”的出版工作得到了国内外学者的鼎力襄助，国内的专家不仅提供了中肯的选题指导，还不辞劳苦地担任了翻译和审校的工作；而原书的作者也相当关注其作品在中国的传播，有的还专诚为其书的中译本作序。迄今，“计算机科学丛书”已经出版了近百个品种，这些书籍在读者中树立了良好的口碑，并被许多高校采用为正式教材和参考书籍，为进一步推广与发展打下了坚实的基础。

随着学科建设的初步完善和教材改革的逐渐深化，教育界对国外计算机教材的需求和应用都步入一个新的阶段。为此，华章公司将加大引进教材的力度，在“华章教育”的总规划之下出版三个系列的计算机教材：除“计算机科学丛书”之外，对影印版的教材，则单独开辟出“经典原版书库”；同时，引进全美通行的教学辅导书“Schaum's Outlines”系列组成“全美经典学习指导系列”。为了保证这三套丛书的权威性，同时也为了更好地为学校和老师们服务，华章公司聘请了中国科学院、北京大学、清华大学、国防科技大学、复旦大学、上海交通大学、南京大学、浙江大学、中国科技大学、哈尔滨工业大学、西安交通大学、中国人民大学、北京航空航天大学、北京邮电大学、中山大学、解放军理工大学、郑州大学、湖北工学院、中国国

家信息安全测评认证中心等国内重点大学和科研机构在计算机的各个领域的著名学者组成“专家指导委员会”，为我们提供选题意见和出版监督。

这三套丛书是响应教育部提出的使用外版教材的号召，为国内高校的计算机及相关专业的教学度身订造的。其中许多教材均已为M. I. T.，Stanford，U.C. Berkeley，C. M. U. 等世界名牌大学所采用。不仅涵盖了程序设计、数据结构、操作系统、计算机体系结构、数据库、编译原理、软件工程、图形学、通信与网络、离散数学等国内大学计算机专业普遍开设的核心课程，而且各具特色——有的出自语言设计者之手、有的历经三十年而不衰、有的已被全世界的几百所高校采用。在这些圆熟通博的名师大作的指引之下，读者必将在计算机科学的宫殿中由登堂而入室。

权威的作者、经典的教材、一流的译者、严格的审校、精细的编辑，这些因素使我们的图书有了质量的保证，但我们的目标是尽善尽美，而反馈的意见正是我们达到这一终极目标的重要帮助。教材的出版只是我们的后续服务的起点。华章公司欢迎老师和读者对我们的工作提出建议或给予指正，我们的联系方法如下：

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About the Authors

James A. Rehg, CMfgE, is an Associate Professor of Engineering at Penn State Altoona, where he teaches automation controls courses in the BS program in Electromechanical Engineering Technology. He earned both a Bachelor of Science degree and a Master of Science degree in Electrical Engineering from St. Louis University and has completed additional graduate study at Wentworth Institute, University of Missouri, South Dakota School of Mines and Technology, and Clemson University. Before coming to Penn State Altoona, he was the CIM coordinator and department head of CAD/CAM/Machine Tool Technology at Tri-County Technical College. Prior to that, he was the Dean of Engineering Technology and Director of Academic Computing at Trident Technical College in Charleston, South Carolina. He held the position of Director of the Robotics Resource Center at Piedmont Technical College in Greenwood, South Carolina, and was department head of Electronic Engineering Technology of Forest Park Community College in St. Louis, Missouri. In addition, he was a Senior Instrumentation Engineer for Boeing in St. Louis. Professor Rehg has authored five texts on robotics and automation and has presented numerous papers on subjects related directly to training in automation and robotics. He has also been a consultant to nationally recognized corporations and many educational institutions. He has led numerous seminars and workshops in the areas of robotics and microprocessors and has developed extensive seminar training material. In addition, he has received numerous state awards for excellence in teaching and was named the outstanding instructor in the nation by the Association of Community College Trustees.

Henry W. Kraebber, PE, CPIM, is a Professor of Mechanical Engineering Technology at Purdue University in West Lafayette, Indiana. He has fifteen years of experience and leadership in manufacturing operations, engineering, quality, and management. He has worked at the Collins Avionics and Missiles group of Rockwell International, the Plough Products Division of Schering-Plough Corporation, and Flavorite Laboratories, Inc. His work has supported the production of industrial, consumer, and military products in the food, consumer products, and electronics areas. He currently teaches courses in manufacturing

operations, manufacturing quality control, and integrated systems in the Computer-Integrated Manufacturing Technology degree program. Mr. Kraebber earned a Bachelor of Science degree in Industrial Engineering from Purdue University and a Master of Engineering degree in Industrial Engineering from Iowa State University. He is President of the CIM in Higher Education (CIM/HE) Alliance, a nonprofit corporation that supports CIM and manufacturing education. He is a senior member of the Society of Manufacturing Engineers (SME) and the Institute of Industrial Engineers (IIE). He is an active member of the American Production and Inventory Control Society (APICS) and has served as President and Vice President of Education for the Wabash Valley Chapter.

This text is dedicated to three very special young men—Jim and Richard Rehg and Karl Kraebber—and to our families, students, and friends, who have helped make this possible.

Preface

The global economy and technological innovations bring many new issues and twists to the subject of computer-integrated manufacturing (CIM). It remains as broad as the complex manufacturing enterprises it attempts to model. Some persons would suggest that CIM is too broad for a single course or textbook. However, the essence of CIM is in the integration of the enterprise elements: physical integration through the linking of hardware and software systems, logical integration through shared common enterprise information and data, and philosophical integration based on a new sense of purpose and direction in every entity in the enterprise. Therefore, the integration so critical to a CIM implementation is best introduced in a single course so that links between the enterprise elements can be explored. This book was written to support such an introductory course.

Understanding the operation of a comprehensive CIM solution requires some study of traditional manufacturing practice, a look at the current state of CIM, and consideration of how technology and operating procedures may change in the future. The integration of product design techniques and fundamental manufacturing principles, along with a look at changing operations and information systems that support CIM throughout the enterprise, makes this book unique. In the book, we do the following:

- Describe the different types of manufacturing systems or production strategies used by industries worldwide. This description is important because no two CIM solutions are the same.
- Go beyond the description of automated machines and software solutions because a successful CIM implementation demands more than technology. In practice, ordering hardware and software is the last step in a CIM implementation; the preliminary work is what guarantees a successful CIM project.
- Discuss the impact of CIM on all the major elements in an enterprise: product design, shop-floor technology, and manufacturing production and operational control systems.
- Provide a convincing argument for implementing CIM so that the enterprise will be competitive in the global market. In practice, the technologies

available to manufacturers around the globe open every market to worldwide competition.

- Look at the computer-based systems of the CIM enterprise that support the growing just-in-time and lean production initiatives.

In addition, the third edition has the following significant changes: Work-cell-design case studies have been added at the end of chapters 1 through 4, 5, 10, and 11, with the work keyed to the concepts presented in the chapters. The chapter on CAD, chapter 4, was changed extensively to an overview of the CAD function in an enterprise and an introduction to product data management (PDM). The enterprise networking concepts were updated and expanded. The finite-element analysis and rapid prototyping sections in chapter 5 were updated and expanded. Numerous new figures have replaced older images, and many new images have been added.

Also new to this edition is a CD-ROM containing the demo version of the WinMan software. This software provides its users with an opportunity to work with a fully functional computer-based enterprise resources planning (ERP) system. This tool allows users to see how a modern data-driven system can help companies better manage their operations and the related data. The CD includes a fully functional single-user system that can be installed on a PC. The demonstration takes users through the basics of the system—from the building of item and structure databases to the functions needed to manage customer orders, material management, manufacturing, and accounting information.

To provide a complete overview of the computer-integrated enterprise, we divided the book into four parts. In the first part, chapters 1 and 2, we provide an overview of global competition, describe an internal manufacturing strategy, discuss in detail the problem facing manufacturing and the development of an effective solution, and characterize the operation of different types of enterprises. In the characterization, we furnish a classification and description of the manufacturing systems and production strategies used by manufacturing, provide an explanation of the product development and engineering change cycle, and give an overview of the enterprise organization. At the end of part 1, the need for change in manufacturing is made clear and a basic strategy for change in the organization is established. In addition, the description of the enterprise organization in part 1 provides a framework for the CIM concepts introduced in the rest of the text. Part 1 provides the critical introduction to manufacturing and the enterprise that is necessary for a course designed to teach CIM.

In part 2, which includes three chapters, we examine the three major design and engineering process segments that take a product from concept to production. Chapter 3 introduces design and production engineering concepts and issues. The use of CIM technology to design and produce world-class products with enhanced enterprise productivity is emphasized. The old design model is compared to a recommended new process that incorporates a concurrent engineering focus to product design. This part of the text concludes with an in-depth description of production engineering functions and the opportunities for productivity gains through integration of technology and data in the enterprise. Computer-aided

design (CAD) is the focus of chapter 4. Since design is the starting point for development of the product database, a full chapter is devoted to the integration of CAD into the enterprise operation. To emphasize this integration, we changed the chapter title and the content to include PDM (product data management). The function of CAD technology in the product design process is discussed, and the systems used to develop the product models are described. The importance of PDM and its link to the CAD technology and design department are covered. In chapter 5, we explore the relationships between the concurrent engineering product design model and the computer-aided engineering (CAE) technology available to support every step of the design process and production engineering. We include a complete definition of CAE, design for manufacturing and assembly, finite-element and mass-properties analysis, rapid prototyping, group technology, computer-aided process planning, computer-aided manufacturing, production and process modeling and simulation, maintenance, automation, and product cost analysis. In the final section of chapter 5, we describe the computer network used to tie the design and production engineering functions to the common enterprise database and other business functions.

Part 3 of the text shifts the CIM focus to controlling the enterprise resources. CIM is alive and growing in applications that support the management and control of the enterprise. The first chapter in the sequence, chapter 6, describes the concept of manufacturing planning and control (MPC) with a model of a typical MPC system. The function of manufacturing planning and a high-level look at the systems and technologies available for CIM implementations are presented. Attention is given to the high-level system elements of production planning and the master production schedule (MPS). Chapter 6 provides an overview of the critical concepts that are explored in more detail in the following two chapters.

In chapter 7, three key elements in the MPC model are discussed in more detail. These include material requirements planning (MRP), capacity requirements planning (CRP), and the production activities that execute the material and capacity plans. Automation software used to implement CIM in this critical part of the enterprise is introduced and explained. Software solutions for the manual MPC functions are included at the end of each section. At the conclusion of chapters 6 through 8, the reader will understand the operation of an MPC system and will be able to follow the logic and calculations of each function in MPC and describe key features of application software capable of automating the MPC functions.

Chapter 8, "Enterprise Resources Planning, and Beyond," develops the links between the concepts from MRP and MRP II systems that are essential parts of the new ERP systems. The pace of change in technology and new systems at the end of the 1990s has been extraordinary. There is no way to predict the future, but it is clear that new systems and system features will continue to be developed. Technologies for design, processing and control, information systems, and communication are rapidly converging. The emerging technologies offer substantial new opportunities and benefits, but also present new challenges for the manufacturing enterprise.

The quiet revolution in manufacturing coming from just-in-time (JIT) manufacturing and lean production methods is the focus of chapter 9. These methods

are based on the elimination of waste throughout the enterprise. The operations and management techniques that are used in JIT and lean systems have deep roots in classic industrial engineering. The methods provide surprising results when they are woven into an integrated system for the operation of the enterprise. Small lot sizes approaching a lot size of 1 unit, visual signals, and expanded work by employee teams are at the heart of this revolution. Computer-based systems still have an important role to play in the support of the JIT and lean production initiatives.

Part 4 concentrates on the processes and systems that lay the foundation for modern manufacturing and enterprise-wide concepts critical to a successful CIM implementation. Chapter 10 covers the commonly used production process machines used in manufacturing. In addition, manufacturing systems including one or more machines, called *flexible manufacturing cells* and *flexible manufacturing systems*, are addressed in the chapter. Chapter 11 covers machines and systems that support production, including coverage of industrial robots, material-handling systems, automatic guided vehicles, and automatic storage and retrieval systems. The techniques used for the control of production systems are the focus of chapter 12. The control systems discussed include cell control hardware and software, device control hardware and software, programmable logic controllers, and computer numerical controllers. The operation and the management of enterprise networks and common databases are also discussed. A successful implementation of any high technology requires a change in the management viewpoint on manufacturing management and human resource development. As a result, a discussion of a broad range of quality issues and the effective use of human resources are included in chapter 13.

In summary, part 1 begins with a global view of manufacturing. In the second and third parts, we focus on the activities required to convert raw material into finished goods and introduce technology to aid in the conversion and the management of the enterprise. The last part of the text shifts back to systems that enable the enterprise to manufacture products competitively, with the discussion centered on the services and support functions required for successful CIM implementation. Common products (hardware, software, and systems) are included throughout the book to demonstrate the technology and to stress the integration issues.

We tried to include important trends and real industrial practices in this text. The inputs from colleagues in industry have contributed directly to the improved content of this edition. Special thanks go out to Patrick Delaney, President of SIBC Corporation; Rick Anderson, President of TTW, Inc.; Kurt Freimuth, President of Factory Floor Solutions; Charlie Colosky, President of Operations Development Associates; and Joel Lemke, President of ENOVIA Corporation, for important inputs and background information.

The logical order of topics and chapter content was tested in a series of workshops at Trident Technical College offered to college faculty and industrial employees. In addition, the text has been used in numerous university courses at Purdue and other institutions. The insight gained through discussions in these settings was

critical to the development of this book. We would especially like to thank John Sjolander, Jerry Bell, and Alan Kalameja for their help with the design automation and control elements. Special thanks to Marci Rehg for her help in developing the CIM workshop material, where many of the presentation ideas were tested. Donald Lucas and Hugo Ramos, former graduate students in the School of Technology at Purdue University, worked on research projects on product lifecycle management that have contributed to this text. Thanks also to all the students who have helped us develop and test instructional materials related to CIM over the years.

Finally, thanks to the IBM Corporation, founders of the initial CIM in Higher Education Alliance program, for support in developing the CIM workshops and the CIM capability at two- and four-year colleges. The CIM in Higher Education Alliance is now an independent, nonprofit corporation that continues to encourage and support CIM and education for manufacturing. Thanks also to the reviewers, Don Arney (Ivy Tech State College, IN) and Dr. Michael Costello (Southern Illinois University at Carbondale).

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