Database Design,
Application Development,
and
Administration
fifth edition

Michael V. Mannino
University of Colorado, Denver

www.mmannino.com
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Preface

Motivating Example

Paul Hong, the owner of International Industrial Adhesives, Inc., is relieved to have survived the recent economic turmoil that has riled many firms and industries. He attributes the success to cost saving efforts on energy consumption, development of new adhesive products for recession resilient industries, partnerships with global partners, and strategic deployment of information technology. His satisfaction about recent performance is tempered by concerns about global economic trends, competitor reactions, and government policies. Large increases in commodity prices have put pressure on profits as the economy has not been strong enough to support price increases for his products. The success of his business has attracted new competitors focusing on his most profitable customers and products. New government environmental and financial regulations impose costly data collection efforts, reporting requirements, and compliance activities. Despite the recent success of his business, he remains cautious about new directions to ensure continued growth of his business.

Paul Hong must make timely and appropriate information technology investments to respond to competitors, reduce the impact of commodity price increases, and control costs of government mandates. To match competitors, he needs more detailed and timely data about industry trends, competitors' actions, and distributor transactions. To reduce the impact of commodity price increases, he must improve procurement systems and reduce raw material usage. To comply with new environmental and financial regulations, he must develop new data collection practices, conduct information technology audits, and fulfill other government reporting requirements for public companies. For all of these concerns, he is unsure about proprietary versus open technologies as well as third party management of platforms and services.

These concerns involve significant usage of database technology as part of a growing enterprise computing infrastructure. Transaction processing features in enterprise DBMSs provide a foundation to ensure reliable data collection efforts for compliance with government regulations. Data warehouse features in enterprise DBMSs provide the foundation to support large data warehouses, capture source data in a timely manner, and efficiently summarize large volumes of data. Parallel database technology can improve performance and reliability of both transaction processing and data warehouse queries through division of processing among available resources. These technologies can be deployed in cloud computing environments that provide economies of scale, elimination of fixed infrastructure costs, and dynamic scalability.

However, the solutions to Paul Hong's concerns are found not just in technology. Utilization of the appropriate level of technology involves a vision for an organization's future, a deep understanding of technology, and traditional management skills to control risk. Paul Hong realizes that his largest challenge is to blend these skills so that effective solutions can be developed for International Industrial Adhesives, Inc.

Introduction

This textbook provides a foundation to understand database technology supporting enterprise computing concerns such as those faced by Paul Hong. As a new student of database management, you first need to understand the fundamental concepts of database management and the relational data model. Then you need to master skills in database design and database application development. This textbook provides tools to help you understand relational databases and acquire skills to solve basic and advanced problems in query formulation, data modeling, normalization, application data requirements, and customization of database applications.

After establishing these skills, you are ready to study the role of database specialists and the
processing environments in which databases are used. This textbook presents the fundamental database technologies in each processing environment and relates these technologies to new advances in electronic commerce and enterprise computing. You will learn the vocabulary, architectures, and design issues of database technology that provide a background for advanced study of individual database management systems, electronic commerce applications, and enterprise computing.

What’s New in the Fifth Edition

The fifth edition makes significant revisions to the fourth edition while preserving the proven pedagogy developed in the first four editions. Experience gained from my own instruction of undergraduate and graduate students along with feedback from adopters of the earlier editions have led to the development of new material and refinements to existing material.

The most significant change in the fifth edition is expansion of data warehouse coverage from one chapter to two chapters. As a response to industry demand for students with training and background on data warehouses, information systems curriculums have added data warehouse coverage in new and existing courses. The expanded coverage in this textbook follows this trend with substantial new material on data modeling concepts for data warehouse design, data warehouse development methodologies, and data integration practices. In the fifth edition, Chapter 16 covers data warehouse concepts and design with substantial new material about data modeling concepts for data warehouses and data warehouse development methodologies. An extended example about the Colorado Education Data Warehouse provides a realistic depiction of data warehouse design. Chapter 17 covers data integration practices and relational DBMS extensions with substantial new material about data integration practices.

Besides the expanded coverage of data warehouses, the fifth edition provides a large amount of additional material and revisions to existing material. Additional material includes data modeling notations in popular CASE tools, cloud computing architectures for database products and services, problems with using government issued identification numbers as primary keys, the Oracle SQL Tuning Advisor, usage of the Oracle SQL Developer tool, triggers for mapping updates of multiple table views, description of standards for benchmark pricing and energy usage specifications, more details about intent locks, update locks for deadlock prevention, and Oracle partitioning options. The fifth edition has made substantial revisions to coverage of SQL standards, the DBMS marketplace, data modeling transformations, histograms, ambiguity about mixing join styles, data requirements for hierarchical forms, Oracle security features, the two phase locking protocol, and the Data Warehouse Maturity Model. In addition, refinements and updates to most chapters have improved the presentation and currency of the material.


For database administration and processing environments, the fifth edition provides expanded coverage of new technology in SQL:2008 and Oracle 11g. The most significant new topics involve the Oracle SQL Developer, Oracle INSTEAD OF triggers for view updates, the Oracle SQL Tuning Advisor, Oracle partitioning options, and Oracle ranking functions. Significantly revised coverage is provided for Oracle security features, the Oracle SQL Access Advisor, and Oracle triggers.

In addition to new material and refinements to existing material, the fifth edition extends the chapter supplements. The fifth edition contains new end-of-chapter questions and problems in most chapters. New material in the textbook’s website includes assignments for first and second database courses and sample exams.
Advantages Over Other Books

This textbook provides outstanding features unmatched in competing textbooks. The unique features include detailed SQL coverage for both Microsoft Access and Oracle, problem-solving guidelines to aid acquisition of key skills, carefully designed sample databases and examples, a comprehensive case study, advanced topic coverage, integrated lab material, coverage of prominent data modeling tools, and extensive data warehouse details. These features provide a complete package for both introductory and advanced database courses. Each of these features is described in more detail in the list below whereas Table P-1 summarizes the competitive advantages by chapter.

- **SQL Coverage**: The breadth and depth of the SQL coverage in this text is unmatched by competing textbooks. Table P-2 summarizes SQL coverage by chapter. Parts 2 and 5 provide thorough coverage of the CREATE TABLE, SELECT, UPDATE, INSERT, DELETE, CREATE VIEW, and CREATE TRIGGER statements. Numerous examples of basic, intermediate, and advanced problems are presented. The chapters in Part 7 cover statements useful for database administrators as well as statements used in specific processing environments.

- **Access and Oracle Coverage**: The chapters in Parts 2 and 5 provide detailed coverage of both Microsoft Access and Oracle SQL. Each example for the SELECT, INSERT, UPDATE, DELETE, and CREATE VIEW statements are shown for both database management systems. Significant coverage of new Oracle 11g SQL features appears in Chapters 8, 9, 11, 15, 17, and 19. In addition, the chapters in Parts 2 and 5 cover SQL:2008 syntax to support instruction with other prominent database management systems.

- **Problem-Solving Guidelines**: Students need more than explanations of concepts and examples to solve problems. Students need guidelines to help structure their thinking process to tackle problems in a systematic manner. The guidelines provide mental models to help students apply the concepts to solve basic and advanced problems. Table P-3 summarizes the unique problem-solving guidelines by chapter.

- **Sample Databases and Examples**: Two sample databases are used throughout the chapters of Parts 2 and 5 to provide consistency and continuity. The University database is used in the chapter examples, while the Order Entry database is used in the end-of-chapter problems. Numerous examples and problems with these databases depict the fundamental skills of query formulation and application data requirements. Revised versions of the databases provide separation between basic and advanced examples. The website contains CREATE TABLE statements, sample data, data manipulation statements, and Access database files for both databases.

- Chapters in Parts 3, 4, and 7 use additional databases to broaden exposure to more diverse business situations. Students need exposure to a variety of business situations to acquire database design skills and understand concepts important to database specialists. The supplementary databases cover water utility operations, patient visits, academic paper reviews, personal financial tracking, airline reservations, placement office operations, automobile insurance, store sales tracking, and real estate sales. In addition, Chapter 16 on data warehouses presents a substantial data warehouse, the Colorado Education Data Warehouse.

- **Comprehensive Case Study**: The Student Loan Limited Case is found at the end of Part 6. The case description along with its solution integrates the concepts students learned in the preceding 12 chapters on application development and database design. The follow-up problems at the end of the chapter provide additional opportunities for students to apply their knowledge on a realistic case.
• Optional Integrated Labs: Database management is best taught when concepts are closely linked to the practice of designing, implementing, and using databases with a commercial DBMS. To help students apply the concepts described in the textbook, optional supplementary lab materials are available on the text’s website. The website contains labs for two Microsoft Access versions (2003 and 2007) as well as practice databases and exercises. The Microsoft Access labs integrate a detailed coverage of Access with the application development concepts covered in Parts 2 and 5.

• Data Modeling Tools: The fifth edition expands coverage of commercial data modeling tools for database development. Students will find details about Aqua Data Studio, Oracle SQL Developer, and Visio Professional 2010.

• Data Warehouse Coverage: The two data warehouse chapters (16 and 17) provide enough details for a third of an advanced database course. The material can support three major assignments, two exams, and a project in an advanced database course.

• Current and Cutting-Edge Topics: This book covers some topics that are missing from competing textbooks: advanced query formulation, updatable views, development and management of stored procedures and triggers, data requirements for data entry forms and reports, view integration, management of the refresh process for data warehouses, the data warehouse maturity model, data integration practices, parallel database architectures, object database architectures, data warehouse features in Oracle 11g, object-relational features in SQL:2008 and Oracle 11g, and transaction design principles. These topics enable motivated students to obtain a deeper understanding of database management.

• Complete Package for Courses: Depending on the course criteria, some students may need to purchase as many as four books for an introductory database course: a textbook covering principles, laboratory books covering details of a DBMS, a supplemental SQL book, and a casebook with realistic practice problems. This textbook and supplemental material provide a complete, integrated, and less expensive source for the student.

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Integrated coverage of client-server processing, parallel database processing, and distributed databases integrated with impact of cloud computing

Advanced topic coverage of object-relational features in SQL:2008 and Oracle 11g

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<td>CREATE TYPE, CREATE TABLE (typed tables and subtables), SELECT (object identifiers, path expressions, dereference operator); SQL:2008 and Oracle coverage</td>
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**Audience**

This book supports two database courses at the undergraduate or graduate levels. At the undergraduate level, students should have a concentration (major or minor) or active interest in information systems. For two-year institutions, the instructor may want to skip the advanced topics and place more emphasis on the optional Access lab book. Undergraduate students should have a first course covering general information systems concepts, spreadsheets, word processing, and possibly a brief introduction to databases.
At the graduate level, this book is suitable in either MBA or Master of Science (in information systems) programs. The advanced material in this book should be especially suitable for Master of Science students.

Except for Chapter 11, a previous course in computer programming can be useful background but is not mandatory. The other chapters reference some computer programming concepts, but writing code is not covered. For a complete mastery of Chapter 11, computer programming background is essential. However, the basic concepts in Chapter 11 can be covered even if students do not have a computer programming background.

**Organization**

As the title suggests, *Database Design, Application Development, and Administration* emphasizes three sets of skills. Before acquiring these skills, students need a foundation about basic concepts. Part 1 provides conceptual background for subsequent detailed study of database design, database application development, and database administration. The chapters in Part 1 present the principles of database management and a conceptual overview of the database development process.

Part 2 provides foundational knowledge about the relational data model. Chapter 3 covers table definition, integrity rules, and operators to retrieve useful information from relational databases. Chapter 4 presents guidelines for query formulation and numerous examples of SQL SELECT statements.

Parts 3 and 4 emphasize practical skills and design guidelines for the database development process. Students desiring a career as a database specialist should be able to perform each step of the database development process. Students should learn skills of data modeling, schema conversion, normalization, and physical database design. The Part 3 chapters (Chapters 5 and 6) cover data modeling using the Entity Relationship Model. Chapter 5 covers the structure of entity relationship diagrams, while Chapter 6 presents usage of entity relationship diagrams to analyze business information needs. The Part 4 chapters (Chapters 7 and 8) cover table design principles and practice for logical and physical design. Chapter 7 covers the motivation, functional dependencies, normal forms, and practical considerations of data normalization. Chapter 8 contains broad coverage of physical database design including the objectives, inputs, file structures, query optimization principles, and important design choices.

Part 5 provides a foundation for building database applications by helping students acquire skills in advanced query formulation, specification of data requirements for data entry forms and reports, and coding triggers and stored procedures. Chapter 9 presents additional examples of intermediate and advanced SQL, along with corresponding query formulation skills. Chapter 10 describes the motivation, definition, and usage of relational views along with specification of view definitions for data entry forms and reports. Chapter 11 presents concepts and coding practices of database programming languages, stored procedures, and triggers for customization of database applications.

Part 6 covers advanced topics of database development. Chapter 12 describes view design and view integration, which are data modeling concepts for large database development efforts. Chapter 13 provides a comprehensive case study that enables students to gain insights about the difficulties of applying database design and application development skills to a realistic business database.

Beyond the database design and application development skills, this textbook prepares students for careers as database specialists. Students need to understand the responsibilities, tools, and processes employed by data administrators and database administrators as well as the various environments in which databases operate.

The chapters in Part 7 emphasize the role of database specialists and the details of managing databases in various operating environments. Chapter 14 provides a context for the other chapters through coverage of the responsibilities, tools, and processes used by database administrators and data administrators. The other chapters in Part 4 provide a foundation for managing databases in important
environments: Chapter 15 on transaction processing, Chapters 16 and 17 on data warehouses, Chapter 18 on distributed processing and data, and Chapter 19 on object database management. These chapters emphasize concepts, architectures, and design choices important for database specialists.

**Approach and Theme**

To support acquisition of the necessary skills for learning and understanding application development, database design, and managing databases, this book adheres to three guiding principles:

1. **Combine concepts and practice.** Database management is more easily learned when concepts are closely linked to the practice of designing and implementing databases using a commercial DBMS. The textbook and the accompanying supplements have been designed to provide close integration between concepts and practice through the following features:
   - SQL examples for both Access and Oracle as well as SQL:2008 coverage
   - Emphasis of the relationship between application development and query formulation
   - Usage of data modeling notations supported by professional CASE tools
   - Supplemental laboratory practice chapters that combine textbook concepts with details of commercial DBMSs

2. **Emphasize problem-solving skills.** This book features problem-solving guidelines to help students master the fundamental skills of data modeling, normalization, query formulation, and application development. The textbook and associated supplements provide a wealth of questions, problems, case studies, and laboratory practices in which students can apply their skills. With mastery of the fundamental skills, students will be poised for future learning about databases and change the way they think about computing in general.

3. **Provide introductory and advanced material.** Business students who use this book may have a variety of backgrounds. This book provides enough depth to satisfy the most eager students. However, the advanced parts are placed so that they can be skipped by the less inclined.

**Pedagogical Features**

This book contains the following pedagogical features to help students navigate through chapter content in a systematic fashion:

- **Learning Objectives** focus on the knowledge and skills students will acquire from studying the chapter.

- **Overviews** provide a snapshot or preview of chapter contents.

- **Key Terms** are highlighted and defined in boxed areas as they appear in the chapter.

- **Examples** are clearly separated from the rest of the chapter material for easier review and studying purposes.

- **Running Database Examples** — examples using the University database as well as other databases with clear separation from surrounding text.

- **Closing Thoughts** summarize chapter content in relation to the learning objectives.

- **Review Concepts** are the important conceptual highlights from the chapter, not just a list of
• **Questions** are provided to review the chapter concepts.

• **Problems** help students practice and implement the detailed skills presented in the chapter.

• **References for Further Study** point students to additional sources on chapter content.

• **Chapter Appendixes** provide additional details and convenient summaries of SQL:2008 syntax and other topics beyond the normal chapter coverage.

• At the end of the text, students will find the following additional resources:

  • **Glossary**: Provides a complete list of terms and definitions used throughout the text.
  
  • **Bibliography**: A list of helpful industry, academic, and other printed material for further research or study.
  
  • **Index**: A list of keywords with page references to help readers of the printed edition.

**Microsoft Access Labs**

Lab books for both Microsoft Access 2003 and 2007 are available on the textbook's website. The lab books provide detailed coverage of features important to beginning database students as well as many advanced features. The lab chapters provide a mixture of guided practice and reference material organized into the following chapters:

1. **An Introduction to Microsoft Access**
2. **Database Creation Lab**
3. **Query Lab**
4. **Single Table Form Lab**
5. **Hierarchical Form Lab**
6. **Report Lab**
7. **Pivot Tables**
8. **User Interface Lab**

Each lab chapter follows the pedagogy of the textbook with Learning Objectives, Overview, Closing Thoughts, Additional Practice exercises, and Appendixes of helpful tips. Most lab chapters reference concepts from the textbook for close integration with corresponding textbook chapters. Each lab book also includes a glossary of terms and an index.

**Instructor Resources**

A comprehensive set of supplements for the text and lab manuals is available to adopters.

• Powerpoint slides for each chapter

• Solutions to end of chapter problems for each chapter

• Solutions to end of chapter questions for each chapter

• Access databases for the university and order entry textbook databases

• Oracle SQL statements to create and populate the university and order entry textbook databases
- Files containing SQL statements used in the textbook chapters
- Case studies along with case study solutions
- Assignments used in a first database course. The assignments involve database creation, query formulation, application development with forms, data modeling, and normalization. In addition, a project assignment integrates material about database development and application development.
- Assignments used in a second database course. The assignments involve database creation, triggers, data warehouse design, data integration practices, query formulation for data warehouses, and object relational databases. In addition, projects are provided about Oracle advanced features, benchmark development, and management practices to develop or manage a significant database or data warehouse in an organization.
- Sample exams for a first course in database management
- Sample exams for an advanced course in database management
- Access databases for each lab chapter
- Access databases for end of chapter problems in each lab chapter

Teaching Paths

The textbook can be covered in several orders in a one- or a two-semester sequence. The author has taught a one-semester course with the ordering of relational database basics, query formulation, application development, database development, and database processing environments. This ordering has the advantage of covering the more concrete material (query formulation and application development) before the more abstract material (database development). Lab chapters and assignments are used for practice beyond the textbook chapters. To fit into one semester, advanced topics are skipped in Chapters 8 and 11 to 18.

A second ordering is to cover database development before application development. For this ordering, the author recommends following the textbook chapter ordering: 1, 2, 5, 6, 3, 7, 4, 9, and 10. The material on schema conversion in Chapter 6 should be covered after Chapter 3. This ordering supports a more thorough coverage of database development while not neglecting application development. To fit into one semester, advanced topics are skipped in Chapters 8 and 11 to 18.

A third possible ordering is to use the textbook in a two-course sequence. The first course covers database management fundamentals from Parts 1 and 2, data modeling and normalization from Parts 3 and 4, and advanced query formulation, application development with views, and view integration from Parts 5 and 6. The second course emphasizes database administration skills with physical database design from Part 4, triggers and stored procedures from Part 5, and the processing environments from Part 7 along with additional material on managing enterprise databases. A comprehensive project can be used in the second course to integrate application development, database development, and database administration.

Acknowledgments

The fifth edition is the culmination of many years of instruction, research, and industry experience. Before beginning the first edition, I wrote tutorials, laboratory practices, and case studies. This material was first used to supplement other textbooks. After encouragement from students, this material was used
without a textbook. This material, revised many times through student comments, was the foundation for the first edition. During the development of the first edition, the material was classroom tested for three years with hundreds of undergraduate and graduate students, along with careful review through four drafts by many outside reviewers. The second edition was developed through classroom usage of the first edition for three years, along with teaching an advanced database course for several years. The third edition was developed through three years experience with the second edition in basic and advanced database courses. The fourth edition was developed through three years of instruction with the third edition in beginning and advanced database courses. The fifth edition was developed through two years of instruction with the fourth edition in beginning and advanced database courses.

I wish to acknowledge the excellent support that I have received in completing this project. I thank my many database students, especially those in ISMG6080, ISMG6480, and ISMG4500 at the University of Colorado Denver. Your comments and reaction to the textbook have been invaluable to its improvement.

About the Author

Michael V. Mannino has been involved in the database field since 1980. He has taught database management since 1983 at several major universities (University of Florida, University of Texas at Austin, University of Washington, and University of Colorado Denver). His audiences have included undergraduate MIS students, graduate MIS students, MBA students, and doctoral students as well as corporate employees in retraining programs. He has also been active in database research as evidenced by publications in major journals of the IEEE (Transactions on Knowledge and Data Engineering and Transactions on Software Engineering), ACM (Communications and Computing Surveys), and INFORMS (Informs Journal on Computing and Information Systems Research). His research includes several popular survey and tutorial articles as well as many papers describing original research. Practical results of his research have been incorporated into Chapter 12 on a form-driven approach to database design and Chapter 17 on management of the refresh process.

Dedication

I dedicate this book to my daughters, Julia and Aimee. Your smiles and affection inspire me every day.