AutoCAD 14 Companion*

Essentials of AutoCAD Plus Solid Modeling

James A. Leach

Autodesk.
Registered Author/Publisher

* Ideal for use with *Fundamentals of Graphics Communication* by Bertoline et al or any graphics text.

AutoCAD 14 Companion

James A. Leach
University of Louisville

IRWIN
GRAPHICS
SERIES

WCB
McGraw-Hill

WCB/McGraw-Hill

A Division of The **McGraw·Hill** *Companies*

AutoCAD 14 Companion

This book is printed on acid-free paper.

The Irwin Graphics Series

Providing you with the highest quality textbooks that meet your changing needs requires feedback, improvement, and revision. The team of authors and McGraw-Hill are committed to this effort. We invite you to become part of our team by offering your wishes, suggestions, and comments for future editions and new products and texts.

Please mail or fax your comments to: Jim Leach
c/o McGraw-Hill
1333 Burr Ridge Parkway
Burr Ridge, IL 60521
fax 630-789-6946

TITLES IN THE IRWIN GRAPHICS SERIES INCLUDE:

Technical Graphics Communication, 2e
Bertoline, Wiebe, Miller, and Mohler, 1997

Fundamentals of Graphics Communication, 2e
Bertoline, Wiebe, and Miller, 1998

Engineering Graphics Communication
Bertoline, Wiebe, Miller, and Nasman, 1995

Problems for Engineering Graphics Communication and Technical Graphics Communication Workbook #1, *1995*

Problems for Engineering Graphics Communication and Technical Graphics Communication Workbook #2, *1995*

AutoCAD Instructor Release 12
James A. Leach, 1995

AutoCAD Companion Release 12
James A. Leach, 1995

AutoCAD 13 Instructor
James A. Leach, 1996

AutoCAD 13 Companion
James A. Leach, 1996

AutoCAD 14 Instructor
James A. Leach, 1998

AutoCAD 14 Companion
James A. Leach, 1998

The Companion for CADKEY 97
John Cherng, 1998

Hands-On CADKEY: A Guide to Versions 5, 6, and 7
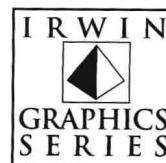*Timothy J. Sexton, 1996*

Modeling with AutoCAD Designer
Dobek and Ranschaert, 1996

Engineering Design and Visualization Workbook
Dennis Stevenson, 1995

Graphics Interactive CD-ROM
Dennis Lieu, 1997

IRWIN
GRAPHICS
SERIES

DEDICATION

To John Damron Collins

"You can do anything if you
just believe in yourself."

PREFACE

ABOUT THIS BOOK

AutoCAD in One Semester
AutoCAD 14 Companion is designed to provide you with the material typically covered in a one-semester AutoCAD course. *AutoCAD 14 Companion* covers the essentials of 2D design and drafting as well as solid modeling.

Your AutoCAD 14 Companion
Because AutoCAD instruction is typically one component of your curriculum, *AutoCAD 14 Companion* is designed to be used in conjunction with other discipline-specific graphics books, such as Technical Graphics Communication or Fundamentals of Graphics Communication by Bertoline, et al.

Graphically Oriented
Because *AutoCAD 14 Companion* discusses concepts that are graphical by nature, many illustrations (approximately **1000**) are used to communicate the concepts, commands, and applications.

Pedagogical Progression
AutoCAD 14 Companion begins with small pieces of information explained in a simple form and then builds on that experience to deliver more complex ideas, requiring a synthesis of earlier concepts. The chapter exercises follow the same progression, beginning with a simple tutorial approach and ending with more challenging problems requiring a synthesis of earlier exercises.

Easy Upgrade from Release 12 or 13
AutoCAD 14 Companion is helpful if you are already an AutoCAD user but upgrading from Release 12 or 13. Release 13 and Release 14 commands, concepts, features, and variables are denoted by a "R13" or "R14" vertical bar on the edges of the pages. In this way, the book provides a useful reference to AutoCAD topics, but allows you to easily locate the Release 13 and Release 14 features.

Valuable Reference Guide
AutoCAD 14 Companion is structured to be used as a reference guide to AutoCAD. Every command throughout the book is given with a "command table" listing the possible methods of invoking the command. A <u>complete index</u> gives an alphabetical listing of all AutoCAD commands, command options, system variables, and concepts discussed.

For Students in Diverse Areas
AutoCAD 14 Companion is written for students in the fields of engineering, architecture, design, construction, manufacturing, and any other field that has a use for AutoCAD. Applications and examples from many fields are given throughout the text. The applications and examples are not intended to have an inclination toward a particular field. Instead, applications to a particular field are used when they best explain an idea or use of a command.

Additional Topics Available
For instruction in the full range of AutoCAD Release 14's commands and features, you may want to purchase *AutoCAD 14 Instructor* by James A. Leach, WCB/McGraw-Hill. *AutoCAD 14 Instructor* covers all of the topics discussed in this book as well as advanced selection sets, block attributes, external references, object linking and embedding, raster images and other file formats, advanced paper space, wireframe modeling, surface modeling, rendering, creating 2D drawings from 3D models, Internet tools, script and slide files, basic customization, menu customization, bonus features, and a variety of additional reference material. *AutoCAD 14 Instructor* includes 1550 illustrations in 1200 pages.

www.mhhe.com/leach
Please visit our web page at the above address. Beginning early 1998, ancillary material is available for reading or download. Questions (true-false, multiple choice, and written answer) are available for review and testing. Additional drawing problems <u>specifically</u> for architectural, mechanical engineering, and other engineering applications are available. Solutions for drawing problems and questions can be downloaded by requesting a password at the web site.

Have Fun
I predict you will have a positive experience learning AutoCAD. Although learning AutoCAD is not a trivial endeavor, you will have fun learning this exciting technology. In fact, I predict that more than once in your learning experience you will say to yourself, "Cool!" (or something to that effect).

James A. Leach

ABOUT THE AUTHOR

James A. Leach (B.I.D., M.Ed.) is an associate professor of engineering graphics at the University of Louisville. He began teaching AutoCAD at Auburn University early in 1984 using Version 1.4, the first version of AutoCAD to operate on IBM personal computers. Jim is currently the director and primary instructor at the AutoCAD Training Center (ATC) at the University of Louisville, one of the first fifteen centers to be authorized by Autodesk, having been established in 1985.

In his 21 years of teaching Engineering Graphics and AutoCAD courses, Jim has published numerous journal and magazine articles, drawing workbooks, and textbooks about AutoCAD and engineering graphics instruction. He has designed CAD facilities and written AutoCAD-related course materials for Auburn University, University of Louisville, the ATC at the University of Louisville, and several two-year and community colleges. Jim is the author of six AutoCAD textbooks published by Richard D. Irwin and McGraw-Hill.

CONTRIBUTING AUTHORS

Steven H. Baldock is an engineer at a consulting firm in Louisville and operates a CAD consulting firm, Infinity Computer Enterprises (ICE). Steve is an Autodesk Certified Instructor and teaches several courses at the University of Louisville AutoCAD Training Center. He has ten years experience using AutoCAD in architectural, civil, and structural design applications. Steve has degrees in engineering, computer science, and mathematics. Steve Baldock prepared material for several sections of *AutoCAD 14 Companion*, such as, text, and dimensioning. Steve also created several hundred figures used in *AutoCAD 14 Companion*.

Michael E. Beall is the owner of Computer Aided Management and Planning in Shelbyville, Kentucky. Michael offers contract services and professional training on AutoCAD as well as CAP products from Sweets Group, a division of McGraw-Hill. He has recently co-authored *AutoCAD 14 Fundamentals*, and was a contributing author to *Inside AutoCAD 14* from New Riders Publishing. Other efforts include co-authoring *AutoCAD Release 13 for Beginners* and *Inside AutoCAD LT for Windows 95*. He was also author of the ATC certified courseware *AutoCAD Release 13 for the Professional: Level I*, all from New Riders Publishing. Mr. Beall has been presenting CAD training seminars to architects and engineers since 1982 and

is currently an Autodesk Certified Instructor (ACI) at the University of Louisville ATC. He is also a presenter for the *Mastering Today's AutoCAD* seminar series from At.A.Glance, Inc., an organization founded by Hugh Bathurst (www.awarenesslearning.com). Mr. Beall received a Bachelor of Architecture degree from the University of Cincinnati. Michael Beall assisted with several topics in *AutoCAD 14 Companion*. Contact Michael at 502.633.3994 or MBEALL_CAMP@compuserve.com.

ACKNOWLEDGMENTS

I want to thank the contributing authors for their assistance in writing *AutoCAD 14 Companion*. Without their help, this text could not have been as application-specific nor could it have been completed in the short time frame. I especially want to thank Steven H. Baldock for his valuable input and hard work on earlier editions of the AutoCAD textbooks.

I am very grateful to Gary Bertoline for his foresight in conceiving the Irwin Graphics Series and for including my efforts in it.

I would like to give thanks to the excellent editorial and production group at WCB/McGraw-Hill who gave their talents and support during this project, especially Betsy Jones, Kelley Butcher, and Beth Cigler.

A special thanks goes to Karen Collins and Bryan Chamberlain for the layout and design of *AutoCAD 14 Companion*. They were instrumental in fulfilling my objective of providing the most direct and readable format for conveying concepts.

Doug Clark and Kristine Clayton deserve credit for the creation of the "command tables" used throughout the text. Thanks for meeting the deadlines.

I appreciate the time and attention given by Mike Anderson in quality checking the Chapter Exercises with a fine-tooth comb.

I also acknowledge: my colleague and friend, Robert A. Matthews, for his support of this project and for doing his job well; Charles Grantham of Contemporary Publishing Company of Raleigh, Inc., for generosity and consultation; and Speed Scientific School Dean's Office for support and encouragement.

Special thanks, once again, to my wife, Donna, for the many hours of copy editing required to produce this and the other texts.

TRADEMARK AND COPYRIGHT ACKNOWLEDGMENTS

The following drawings used for Chapter Exercises appear courtesy of James A. Leach, *Problems in Engineering Graphics Fundamentals, Series A* and *Series B*, ©1984 and 1985 by Contemporary Publishing Company of Raleigh, Inc.: Gasket A, Gasket B, Pulley, Holder, Angle Brace, Saddle, V-Block, Bar Guide, Cam Shaft, Bearing, Cylinder, Support Bracket, Corner Brace, and Adjustable Mount. Reprinted or redrawn by permission of the publisher.

The following are registered U.S. trademarks (®) of Autodesk, Inc.: 3D Studio, 3D Studio MAX, Advanced Modeling Extension, AME, ATC, AutoCAD, Autodesk LT, Autodesk, Autodesk Animator, AutoLISP, AutoShade, AutoSurf, AutoVision, Heidi, and Mechanical Desktop. The following are currently pending U.S. trademarks (™) of Autodesk, Inc.: Autodesk Device Interface, AutoFlix, AutoSnap, DXF, FLI, FLIC, Kinetix, and ObjectARX. All AutoCAD Release 13 and Release 14 sample drawings appearing throughout the text are reprinted courtesy of Autodesk, Inc. Windows 95, Windows NT,

Notepad, WordPad, Excel, and MS-DOS are registered trademarks of Microsoft Corporation. Corel WordPerfect is a registered trademark of Corel, Inc. Norton Editor is a registered trademark of S. Reifel & Company. City Blueprint, Country Blueprint, EuroRoman, EuroRoman-oblique, PanRoman, Super-French, Romantic, Romantic-bold, Sans Serif, Sans Serif-bold, Sans Serif-oblique, Sans Serif-BoldOblique, Technic Technic-light, and Technic-bold are Type 1 fonts, copyright 1992 P. B. Payne.

LEGEND

The following special treatment of characters and fonts in the textual content is intended to assist you in translating the meaning of words or sentences in *AutoCAD 14 Companion.*

<u>Underline</u>	Emphasis of a word or an idea.
Helvetica font	An AutoCAD prompt appearing on the <u>screen</u> at the command line or in a text window.
Italic (Upper and Lower)	An AutoCAD command, option, menu, toolbar, or dialog box name.
UPPER CASE	A file name.
UPPER CASE ITALIC	An AutoCAD system variable or a drawing aid (*OSNAP, SNAP, GRID, ORTHO*).

Anything in **Bold** represents user input:

Bold	What you should <u>type</u> or press on the keyboard.
Bold Italic	An AutoCAD <u>command</u> that you should type or <u>menu item</u> that you should select.
BOLD UPPER CASE	A <u>file name</u> that you should type.
BOLD UPPER CASE ITALIC	A <u>system variable</u> that you should type.
PICK	Move the cursor to the indicated position on the screen and press the <u>select</u> button (button #1 or left mouse button).

TABLE OF CONTENTS

INTRODUCTION

WHAT IS CAD?

CAD is an acronym for Computer-Aided Design or Computer-Aided Drafting. CAD allows you to accomplish design and drafting activities using a computer. A CAD software package, such as AutoCAD, enables you to create designs and generate drawings to document those designs.

Design is a broad field involving the process of making an idea into a real product or system. The design process requires repeated refinement of an idea or ideas until a solution results—a manufactured product or constructed system. Traditionally, design involves the use of sketches, drawings, renderings, 2-dimensional and 3-dimensional models, prototypes, testing, analysis, and documentation. Drafting is generally known as the production of drawings that are used to document a design for manufacturing or construction or to archive the design.

CAD is a tool that can be used for design and drafting activities. CAD can be used to make "rough" idea drawings, although it is more suited to creating accurate finished drawings and renderings. CAD can be used to create a 2-dimensional or 3-dimensional computer model of the product or system for further analysis and testing by other computer programs. In addition, CAD can be used to supply manufacturing equipment such as lathes, mills, laser cutters, or rapid prototyping equipment with numerical data to manufacture a product. CAD is also used to create the 2-dimensional documentation drawings for communicating and archiving the design.

The tangible result of CAD activity is usually a drawing generated by a plotter or printer but can be a rendering of a model or numerical data for use with another software package or manufacturing device. Regardless of the purpose for using CAD, the resulting drawing or model is stored in a CAD file. The file consists of numeric data in binary form usually saved to a magnetic or optical device such as a diskette, hard disk, tape, or CD.

WHY SHOULD YOU USE CAD?

Although there are other methods used for design and drafting activities, CAD offers the following advantages over other methods in many cases:

1. Accuracy
2. Productivity for repetitive operations
3. Sharing the CAD file with other software programs

Accuracy

Since CAD technology is based on computers, it offers great accuracy compared to older "manual" methods of drafting and design. When you draw with a CAD system, the graphical elements, such as lines, arcs, and circles, are stored in the CAD file as numeric data. CAD systems store that numeric data with great precision. For example, AutoCAD stores values with fourteen significant digits. The value 1, for example, is stored in scientific notation as the equivalent of 1.0000000000000. This precision provides you with the ability to create designs and drawings that are 100% accurate for almost every case.

Productivity for Repetitive Operations

It may be faster to create a simple "rough" drawing, such as a sketch by hand (pencil and paper), than it would by using a CAD system. However, for larger and more complex drawings, particularly those involving similar shapes or repetitive operations, CAD methods are very efficient. Any kind of shape or operation accomplished with the CAD system can be easily duplicated since it is stored in a CAD file. In

short, it may take some time to set up the first drawing and create some of the initial geometry, but any of the existing geometry or drawing setups can be easily duplicated in the current drawing or for new drawings.

Likewise, making changes to a CAD file (known as editing) is generally much faster than making changes to a traditional manual drawing. Since all the graphical elements in a CAD drawing are stored, only the affected components of the design or drawing need to be altered, and the drawing can be plotted or printed again or converted to other formats.

As CAD and the associated technology advance and software becomes more interconnected, more productive developments are available. For example, it is possible to make a change to a 3-dimensional model that automatically causes a related change in the linked 2-dimensional engineering drawing. One of the main advantages of these technological advances is productivity.

Sharing the CAD File with Other Software Programs

Of course, CAD is not the only form of industrial activity that is making technological advances. Most industries use computer software to increase capability and productivity. Since software is written using digital information and may be written for the same or similar computer operating systems, it is possible and desirable to make software programs with the ability to share data or even interconnect, possibly appearing simultaneously on one screen.

For example, word processing programs can generate text that can be imported into a drawing file, or a drawing can be created and imported into a text file as an illustration. (This book is a result of that capability.) A drawing created with a CAD system such as AutoCAD can be exported to a finite element analysis program that can read the computer model and compute and analyze stresses. CAD files can be dynamically "linked" to spreadsheets or databases in such a way that changing a value in a spreadsheet or text in a database can automatically make the related change in the drawing, or vice versa.

Another advance in CAD technology is the automatic creation and interconnectivity of a 2-dimensional drawing and a 3-dimensional model in one CAD file. With this tool, you can design a 3-dimensional model and have the 2-dimensional drawings automatically generated. The resulting set has bi-directional associativity; that is, a change in either the 2-dimensional drawings or the 3-dimensional model is automatically updated in the other.

CAD, however, may not be the best tool for every design related activity. For example, CAD may help develop ideas but probably won't replace the idea sketch, at least not with present technology. A 3-dimensional CAD model can save much time and expense for some analysis and testing but cannot replace the "feel" of an actual model, at least not until virtual reality technology is developed and refined.

With everything considered, CAD offers many opportunities for increased accuracy, productivity, and interconnectivity. Considering the speed at which this technology is advancing, many more opportunities are rapidly obtainable. However, we need to start with the basics. Beginning by learning to create an AutoCAD drawing is a good start.

WHY USE AutoCAD?

CAD systems are available for a number of computer platforms: laptops, personal computers (PCs), workstations, and mainframes. AutoCAD, offered to the public in late 1982, was one of the first PC-based CAD software products. Since that time, it has grown to be the world leader in market share for

all CAD products. Autodesk, the manufacturer of AutoCAD, is the world's leading supplier of PC design software and multimedia tools. At the time of this writing, Autodesk is the fifth largest software producer in the world and has three million customers in more than 150 countries.

Learning AutoCAD offers a number of advantages to you. Since AutoCAD is the most widely used CAD software, using it gives you the highest probability of being able to share CAD files and related data and information with others.

As a student, learning AutoCAD, as opposed to learning another CAD software product, gives you a higher probability of using your skills in industry. Likewise, there are more employers who use AutoCAD than any other single CAD system. In addition, learning AutoCAD as a first CAD system gives you a good foundation for learning other CAD packages because many concepts and commands introduced by AutoCAD are utilized by other systems. In some cases, AutoCAD features become industry standards. The .DXF file format, for example, was introduced by Autodesk and has become an industry standard for CAD file conversion between systems.

As a professional, using AutoCAD gives you the highest possibility that you can share CAD files and related data with your colleagues, vendors, and clients. Compatibility of hardware and software is an important issue in industry. Maintaining compatible hardware and software allows you the highest probability for sharing data and information with others as well as offering you flexibility in experimenting with and utilizing the latest technological advancements. AutoCAD provides you with the greatest compatibility in the CAD domain.

This introduction is not intended as a selling point but to remind you of the importance and potential of the task you are about to undertake. If you are a professional or a student, you have most likely already made up your mind that you want to learn to use AutoCAD as a design or drafting tool. If you have made up your mind, then you can accomplish anything. Let's begin.

TABLE OF CONTENTS