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A Concise Introduction to

Logic

Fourteenth Edition

Patrick J. Hurley

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To Linda

It is wrong always, everywhere, and for anyone, to believe anything upon insufficient evidence.

—**W. K. Clifford**

Nothing can be more important than the art of formal reasoning according to true logic.

—**Gottfried Wilhelm Leibniz**

Brief Contents

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Preface

The most immediate benefit derived from the study of logic is the skill needed to construct sound arguments of one's own and to evaluate the arguments of others. In accomplishing this goal, logic instills a sensitivity for the formal component in language, a thorough command of which is indispensable to clear, effective, and meaningful communication. On a broader scale, by focusing attention on the requirement for reasons or evidence to support our views, logic provides a fundamental defense against the prejudiced and uncivilized attitudes that threaten the foundations of our democratic society. Finally, through its attention to inconsistency as a fatal flaw in any theory or point of view, logic proves a useful device in disclosing ill-conceived policies in the political sphere and, ultimately, in distinguishing what makes sense from what makes no sense. This book is written with the aim of securing these benefits.

Note to the Instructor

The image on the front cover is intended to convey the message that logic is the key to all learning. Keys open doors. Logic is the key that opens the door to reasoned discourse and dialogue, unlocking an important opportunity for learning. Through logic, students learn to support their views with reasons and to open their minds to the reasons of others. Logic creates a common foundation upon which individuals who hold opposing points of view can learn from each other. What might otherwise devolve into a shouting match of conflicting opinions becomes a venue for the rational exchange of ideas.

To promote the achievement of this goal, this new edition adopts the theme that learning logic is empowering. In this context, saying that logic is empowering does not mean that logic is properly used to overpower one's opponents, to smash their arguments. Rather, it means that logic empowers both the arguer and the listener to enter into a rational exchange where each is free to explore the strengths and weaknesses of the arguments presented on both sides. Logic lays the foundation for a meeting of minds and is therefore one of the great civilizing elements in human society. To implement the empowerment theme, each chapter begins with a brief selection explaining how the content of the chapter is empowering. While the inclusion of these selections may be the most visible change in the new edition, as you proceed through the book, you will encounter additional improvements that are less visible.

New to This Edition

Each chapter of the book now begins with a signature paragraph explaining how and why the content of the chapter is empowering. These "Empowerment" selections replace the "How Logical Are You?" selections in the prior edition. Examples and exercises throughout the book have been updated, featuring current situations and young personalities drawn from an ethnically diverse population that students will readily recognize. In the section relating to induction, more treatment is given to probabilities and odds, and how to compute the one from the other. Further, in the final chapter, new treatment is given to the corrupting influence of corporate money on what we take to be scientific truth. From the start, a chief motivator of this new edition has been Diversity and Inclusion. The book has been especially tuned to respect and value all individuals, regardless of marital status, gender, ethnicity, religious orientation, or socioeconomic status. We are committed to the view that such a perspective constitutes the best environment for learning anything, and it will help students feel at home when studying logic.

Hallmark Features

- Chapters are organized so that earlier sections provide the foundation for later ones. Later sections can be skipped by instructors opting to do so.

- The main points are always presented up front so students cannot possibly miss them.

- Relevant and up-to-date examples are used extensively.

- Key terms are introduced in boldface type and defined in the Glossary/Index.

- Central concepts are illustrated in graphic boxes.

- Numerous exercises, many drawn from real-life sources such as newspapers, textbooks, and magazines, are included to perfect student skills—the current edition includes over 2,700 exercises.

- Biographical vignettes of prominent logicians are included to give logic a human face.

- Dialogue exercises illustrate the application of logical principles to real-life situations.

- Venn diagrams for syllogisms are presented in a novel and more effective way, using color to identify the relevant areas.

- End-of-chapter summaries facilitate student review.

- The solution to every third exercise is provided in the Answers to Selected Exercises section, so students can easily check their work.

- A robust digital platform offers thousands of autograded practice questions that boost students' confidence in mastering logic. These are accompanied by video and tutorial help resources.

- Multimedia resources, such as Learning Logic, offer students stepped-out tutorials on challenging Logic concepts and applications.

Ways of Approaching This Textbook

In general, the material in each chapter is arranged so that certain later sections can be skipped without affecting subsequent chapters. For example, those wishing a brief treatment of natural deduction in both propositional and predicate logic may want to skip the last three sections of Chapter 7 and the last four (or even five) sections of Chapter 8. Chapter 2 can be skipped altogether, although some may want to cover the first section of that chapter as an introduction to Chapter 3. Finally, Chapters 9 through 14 depend only slightly on earlier chapters, so these can be treated in any order one chooses. However, Chapter 14 does depend in part on Chapter 13.

Type of Course

	Traditional logic course	**Informal logic course, critical-reasoning course**	**Course emphasizing modern formal logic**
Recommended material	Chapter 3 Chapter 4 Chapter 5 Chapter 6 Sections 7.1–7.4	Chapter 1 Chapter 2 Chapter 3 Chapter 4 Sections 5.1–5.3 Sections 5.5–5.6 Sections 6.1–6.4 Section 6.6 Chapter 9 Chapter 12 Chapter 13 Chapter 14 *Critical Thinking and Writing supplement*	Chapter 1 Sections 4.1–4.3 Section 4.7 Sections 6.1–6.5 Chapter 7 Chapter 8 *Truth Trees* supplement
Optional material	Chapter 2 Sections 7.5–7.7 Chapters 9–14	Section 5.4 Section 5.7 Section 6.5 Chapter 10 Chapter 11	Chapter 3 Sections 4.4–4.6 Sections 5.1–5.2 Section 5.7 Section 6.6

To the Student

Imagine that you are interviewing for a job. The person across the desk asks about your strengths, and you reply that you are energetic, enthusiastic, and willing to work long hours. Also, you are creative and innovative, and you have good leadership skills. Then the interviewer asks about your reasoning abilities. You reply that you have always considered your reasoning abilities to be excellent.

"Can you point to any evidence of this ability?" the interviewer asks.

"Well," you reply, "in college I took a course in logic, and I easily earned an 'A.'"

"I'm impressed," says the interviewer. "You sound like exactly the kind of job candidate we are looking for. Your reasoning abilities will combine with your other talents for a powerful effect."

"I'm happy to hear you say that," you reply. "But could you elaborate on that last point?"

"I'll be happy to," the interviewer says. "Reasoning skills are essential to good judgment. Your reasoning ability and good judgment will combine with your creativity to yield projects that truly benefit our company, they will convince our other employees that you are leading them in the right direction, and they will blend with your enthusiasm to inspire others to do their best. Further, your willingness to work long hours will guarantee that your efforts will pay off in the end."

"Then, does that mean that you have a place for me?" you ask.

"Absolutely," says the interviewer. "I will be delighted to recommend you for a highly responsible position in our company."

The point of this brief dialogue is that good reasoning skills are essential to doing anything right. The businessperson uses reasoning skills in writing a report or preparing a presentation, the scientist uses them in designing an experiment or clinical trial, the department manager uses them in maximizing worker efficiency, and the lawyer uses them in composing an argument to a judge or jury. And that's where logic comes in. The chief purpose of logic is to develop good reasoning skills. In fact, logic is so important that when the liberal arts program of studies was formulated fifteen hundred years ago, logic was selected as one of the original seven liberal arts. Logic remains to this day a central component of a college or university education.

From a more pragmatic angle, logic is important to earning a good score on any of the several tests required for admission to graduate professional schools—the LSAT, GMAT, MCAT, GRE, and so on. Obviously, the designers of these tests recognize that the ability to reason logically is a prerequisite to success in these fields. Also, logic is a useful tool in relieving what has come to be called math anxiety. For whatever reason, countless students today are terrified of any form of reasoning that involves abstract symbols. If you happen to be one of these students, you should find it relatively easy to master the use of logical symbols, which are closely tied to ordinary language, and your newly found comfort with these symbols will carry over into the other, more difficult fields.

In addition to the existing and new features described in the "New to This Edition" section of this preface, WebAssign also includes the following supplements. *Critical Thinking and Writing* offers practice in writing arguments about real-life topics; *Truth Trees* present a standard introduction to the method of truth trees, which can be used as a supplement or alternative to the truth-table method; and *Logic and Graduate-Level Admission Tests* shows how the principles learned in studying logic can be used to answer questions on the LSAT, GMAT, MCAT, and GRE. Finally, *Existential Import* traces the history of existential import through the logic of Aristotle and George Boole.

Why Learning Logic Is Empowering

In 2019, Stanford Graduate School of Education published the results of a study of 11,000 letters written by teenaged students to the 2016 U.S. presidential candidates.

One might have expected that the letters would have been filled with bombastic language or emotionally charged appeals to the candidates. But no. What the researchers found is that the majority of letters appealed to logic in expressing their point. The students used reasons and evidence to present their positions. There had been no required format to follow in writing these letters, so why the appeal to logic?

As we will see throughout this textbook, logic empowers both arguer and listener. Nonlogical strategies are often coercive, manipulative, and dishonest. Sometimes evidence is withheld, or the arguer attempts to make the listener feel threatened or emotionally overwhelmed. The goal of such strategies is to trick listeners into believing something they might not believe if all the relevant evidence were made available. Trickery fails to respect the listener's ability to evaluate evidence rationally. And it is counterproductive for the arguer, since the listener typically ends up feeling cheated rather than convinced.

Empowerment through logic is very different from attempting to gain power over other people by manipulating or coercing them. For example, suppose someone tries to get you to believe something by making you feel afraid—afraid of losing something like social status or money. In the end, if you are taken in by the manipulator's scheme, the manipulator "wins" and you "lose." You believe something, not on the basis of freely understanding that a conclusion follows on the basis of evidence, but rather as an outcome of coercion. This type of manipulation is a zero-sum game. There is only one winner. If the manipulation succeeds, the manipulator wins and you lose.

Logical reasoning, on the other hand, is a win-win strategy. The arguer presents evidence or reasons relevant to the conclusion, and, if the reasoning is solid, the listener is persuaded and freely consents to the conclusion. In effect, the arguer presents evidence in a way that invites listeners to open their minds to new ways of evaluating the evidence presented. The effectiveness of logical persuasion is manifest by the listener's free embrace of the conclusion advanced. Once listeners understand how the conclusion follows from the evidence, they freely accept the conclusion and make it their own. The listeners are then motivated to present the same line of reasoning to others. In this manner, logical reasoning provides a solid basis for consensus building.

Logic provides a set of basic principles that are the same for everyone. It resembles mathematics in this respect. Mathematical reasoning is so convincing because, if you follow the rules, you can't go astray. It provides a sure and solid foundation for arriving at conclusions. Logic does the same thing. Because the rules of logic are universal in the same way that the rules of math are universal, there is no opportunity for manipulation or fabrication. The rules work equally to everyone's advantage. Everyone wins. In this way, logic is the foundation of all productive negotiations. Good arguments facilitate a meeting of minds. Good arguments facilitate mutual understanding and encourage cooperation. In effect, logic may be the most powerful engine for preserving peace yet created by the human mind.

Online Learning Platform: WebAssign

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- Watch videos and tutorials when you're stuck
- Perform better on in-class activities

Ancillaries for the Instructor

Additional instructor resources for this product are available online at the Cengage Instructor Center—an all-in-one resource for class preparation, presentation, and testing. Resources available for download from the Cengage Instructor Center include:

Instructor's Manual

Includes solutions to all the exercises in the textbook.

Solutions and Answer Guide

This manual contains solutions to all exercises from the text, including Chapter Review Exercises and Chapter Tests, located in the instructor companion site and the WebAssign Resources tab.

Cengage Testing Powered by Cognero

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Educator's Guide

Describes the content and activities available in the accompanying WebAssign course—including videos, prebuilt assignments, and other exercise types—that you can integrate into your course to support your learning outcomes and enhance student engagement and success.

Acknowledgments

For their reviews and suggestions leading to this fourteenth edition I want to thank the following:

Benjamin Arah, Bowie State University; Philip Blosser, Sacred Heart Major Seminary; Michael Clabaugh, College of St. Scholastica; Steven Gerrard, Williams College; Yan Mikhaylov, College of Southern Nevada; Dr. Teresa I. Reed, Quincy University; Robert Robinson, City College of New York-CUNY; Adam R. Thompson, University of Nebraska-Lincoln; Elizabeth J.M. Wakeman, The College of Idaho.

Of course any errors or omissions that may remain are the result of my own oversight.

Those who have contributed reviews and suggestions leading to the thirteen previous editions, and to whom I express my continued thanks, are the following:

Karl Aho, Baylor University; James T. Anderson, University of San Diego; Carol Anthony, Villanova University; Benjamin Arah, Bowie State University; Joseph Asike, Howard University; Harriet E. Baber, University of San Diego; Kent Baldner, Western Michigan University; James Baley, Mary Washington College; Jerome Balmuth, Colgate University; Victor Balowitz, State University of New York, College at Buffalo; Ida Baltikauskas, Century College; Gary Baran, Los Angeles City College; Robert Barnard, University of Mississippi; Peter Barry, Saginaw Valley State University; Gregory Bassham, Kings College; Thora Bayer, Xavier University of Louisiana; David Behan, Agnes Scott College; John Bender, Ohio University, Athens; James O. Bennett, University of Tennessee, Knoxville; Victoria Berdon, IUPU Columbus; Robert Berman, Xavier University of Louisana; Kevin Berry, Ohio University; Joseph Bessie, Normandale Community College; John R. Bosworth, Oklahoma State University; Andrew Botterell, University of Toronto; Jeff Broome, Arapahoe Community College; Tom Browder, University of Nevada, Las Vegas; Harold Brown, Northern Illinois University; Kevin Browne, Indiana University Southeast; Ken Buckman, University of Texas, Pan American; Robert Burch, Texas A&M University; Keith Burgess-Jackson, University of Texas, Arlington; Michael Byron, Kent State University; Scott Calef, Ohio Wesleyan University; Gabriel Camacho, El Paso Community College; James Campbell, University of Toledo; Joseph Keim Campbell, Washington State University; Loren Cannon, Humboldt State University; Charles Carr, Arkansas State University; William Carroll, Coppin State University; Jennifer Caseldine-Bracht, IUPU Fort Wayne; John Casey, Northern Illinois University; Robert Greg Cavin, Cypress College; Ping-Tung Chang, University of Alaska; Prakash Chenjeri, Southern Oregon University; Drew Christie, University of New Hampshire; Timothy Christion, University of North Texas; Ralph W. Clarke, West Virginia University; David Clowney, Rowan University; Darryl Cohen, Mesa Community College; Michael Cole, College of William and Mary; Michael Coledu, Reedley College; Louis Colombo, Bethune-Cookman University; Michael J. Colson, Merced College; William F. Cooper, Baylor University; William Cornwell, Salem State College; Victor Cosculluela, Polk Community College;

Mike Coste, Front Range Community College; Ronald R. Cox, San Antonio College; Houston A. Craighead, Winthrop University; Donald Cress, Northern Illinois University, DeKalb; Richard La Croix, State University College at Buffalo; Jack Crumley, University of San Diego; Rosibel Cruz, Harold Washington College; Drew Dalton, Florida Southern College; Linda Damico, Kennesaw State University; Ray Darr, Southern Illinois University; William J. DeAngelis, Northeastern University; Joseph DeMarco, Cleveland State University; Paul DeVries, Wheaton College; Jill Dieterle, Eastern Michigan University; Mary Domski, University of New Mexico; Beverly R. Doss and Richard W. Doss, Orange Coast College; Paul Draper, Purdue University; William A. Drumin, King's College, Pennsylvania; Clinton Dunagan, Saint Philips College; Jeffrey Easlick, Saginaw Valley State University; Benjamin Easton, Azusa Pacific University; Paul Eckstein, Bergen Community College; Anne M. Edwards, Austin Peay State University; Samantha Emswiler, John Tyler Community College; Michael Epperson, California State University, Sacramento; Lenore Erickson, Cuesta College; Cassandra Evans, San Diego City College; Frank Fair, Sam Houston State University; Evan Fales, University of Iowa; Thompson Faller, University of Portland; William Ferraiolo, San Joaquin Delta College; Albert Filice, Mesa Community College; Lewis S. Ford, Old Dominion University; Gary Foulk, Indiana State University, Terre Haute; Timothy C. Fout, University of Louisville; LeAnn Fowler, Slippery Rock University; Craig Fox, California University of Pennsylvania; Thomas H. Franks, Eastern Michigan University; Bernard D. Freydberg, Slippery Rock University; Thomas J. Frost, Biola University/Long Beach City College; Dick Gaffney, Siena College; George Gale, University of Missouri–Kansas City; Pieranna Garavaso, University of Minnesota at Morris; Paul Gass, Coppin State University; Dimitria Gatzia, The University of Akron Wayne College; Dimitria Gatzia, University of Akron Wayne College; Joseph Georges, El Camino College; Kevin Gibson, University of Colorado; James Granitto, Santiago Canyon College; Victor Grassian, Los Angeles Harbor College; Catherine Green, Rockhurst University; James Greene, Northern Michigan University; Harold Greenstein, SUNY Brockport; J. Randall Groves, Ferris State University; Shahrokh Haghighi, California State University; Alexander W. Hall, Clayton State University; Dean Hamden, Montclair State University; Courtney Hammond, Cuyamaca College; Ken Hanly, Brandon University; Anthony Hanson, West Valley College; Merle Harton, Edward Waters College; Larry Hauser, Alma College; Deborah Heikes, University of Alabama in Huntsville; Ryan Hickerson, Western Oregon University; Douglas Hill, Saddleback College and Golden West College; Ronald Hill, University of San Diego; Lawrence Hinman, University of San Diego; Lynn Holt, Mississippi State University; Jeremy Hovda, Minneapolis Community & Technical College; John B. Howell, III, Southwestern Baptist Theological Seminary; R. I. G. Hughes, University of South Carolina, Columbia; Peter Hutcheson, Texas State University; Debby Hutchins, Gonzaga University; William H. Hyde, Golden West College; Ron Jackson, Clayton State University; William Jamison, University of Alaska Anchorage; Sandra Johanson, Green River Community College; Richard A. Jones, Howard University; Russel Jones, University of Oklahoma; Gary Jones, University of San Diego; Glenn C. Joy, Texas State University, San Marcos; Olin Joynton, North Harris County College; Grant Julin, St. Francis University; Patrick Kenny, Onondaga Community College; Glen Kessler, University of Virginia; Charles F. Kielkopf, Ohio State University; Moya Kinchla, Bakersfield College; Kristin Klamm-Doneen, Anoka Ramsey Community College; Bernard W. Kobes, Arizona State University; Keith W. Krasemann, College of DuPage; Sandra LaFave, West Valley College, Saratoga, California; William Lawhead, University of Mississippi; Stephen Leach, University of Texas–Pan American; Stephen Leach, UTPA; Richard Lee, University of Arkansas; Lory Lemke, University of Minnesota, Morris; Robert Levis, Pasadena City College; Chenyang Li, Monmouth College,

Monmouth, Illinois; Chris M. Lorkowski, Kent State University; Chris Lorkowski, Kent State University–Trumbull Campus; Keane Lundt, Massachusetts College of Liberal Arts; Ardon Lyon, City University of London; Scott MacDonald, University of Iowa; Ian MacKinnon, The University of Akron; Krishna Mallick, Salem State College; Thomas Manig, University of Missouri–Columbia; James Manns, University of Kentucky; Dalman Mayer, Bellevue Community College; Larry D. Mayhew, Western Kentucky University; Leemon McHenry, California State University Northridge; Robert McKay, Norwich University; Rick McKita, Colorado State University; Phillip McReynolds, Pennsylvania State University; Erik Meade, Southern Illinois University–Edwardsville; Noel Merino, Humboldt State University; Kenneth R. Merrill, University of Oklahoma; Daniel Metz, Metropolitan State College of Denver (Program chair at CCCOnline); Daniel Metz, Metropolitan State College of Denver; Thomas Michaud, Wheeling Jesuit College; George D. Miller, DePaul University; Richard Miller, East Carolina University; Alexander Miller, Piedmont Technical College; Dolores Miller, University of Missouri–Kansas City; Frederick Mills, Bowie State University; Jeff Mitchell, Arkansas Tech University; John Mize, Long Beach City College; Mike Monge, Orange Coast College; Allyson Mount, Keene State College; Seyed Mousavian, University of Alberta; Dwayne Mulder, California State University, Fresno; John D. Mullen, Dowling College; Madeline Muntersbjorn, University of Toledo; Henry Nardone, Kings College; Nathaniel Nicol, Washington State University; Theresa Norman, South Texas Community College; David O'Connor, Seton Hall University; Tim O'Neill, Rochester Community and Technical College; Elane O'Rourke, Moorpark College; Brendan O'Sullivan, Rhodes College; Len Olsen, Georgia Southern University; Stephen Pacheco, University of San Diego; Joseph Pak, Los Angeles City College; Christopher Pallotti, Los Angeles Valley College/CSUN; Christopher Pearson, Southern Illinois University Edwardsville; Rodney Peffer, University of San Diego; Linda Peterson, University of San Diego; Robert G. Pielke, El Camino College; Cassandra Pinnick, Western Kentucky University; Nelson Pole, Cleveland State University; Norman Prigge, Bakersfield State University; Gray Prince, West Los Angeles College; R. Puligandla, University of Toledo; T. R. Quigley, Oakland University; Nani Rankin, Indiana University at Kokomo; Robert Redmon, Virginia Commonwealth University; Bruce Reichenbach, Augsburg College; Herminia Reyes, San Diego State University; Fernando Rincon-Tellez, Piedmont Technical College; David Ring, Southern Methodist University; Tony Roark, Boise State University; Matthew Roberts, Patrick Henry College; Phyllis Rooney, Oakland University; Michael Rooney, Pasadena City College; Beth Rosdatter, University of Kentucky; Michelle M. Rotert, Rock Valley College; Paul A. Roth, University of Missouri–Saint Louis; Daniel Rothbart, George Mason University; Robert Rupert, University of Colorado, Boulder; Sam Russo, El Camino College; Frank Ryan, Kent State University; Eric Saidel, George Washington University; Kelly Salsbery, Stephen F. Austin State University; Paul Santelli, Siena College; Stephen Satris, Clemson University; Philip Schneider, George Mason University; James D. Schumaker, University of North Carolina at Charlotte; Stephanie Semler, Radford University; Pat Sewell, University of North Texas; Elizabeth Shadish, El Camino College; Joseph G. Shay, Boston College; Candice Shelby, University of Colorado Denver; Janet Simpson, Suffolk County Community College; Robert Skipper, St. Mary's University; Aeon Skoble, Bridgewater State College; Matthew Slater, Bucknell University; Kent Slinker, Pima Community College; Dennis L. Slivinski, California State University, Channel Islands; Joshua Smith, Central Michigan University; Arnold Smith, Youngstown State University; John-Christian Smith, Youngstown State University; Paula Smithka, University of Southern Mississippi; Eric W. Snider, University of Toledo; Joseph Snyder, Anne Arundel Community College; Bob Snyder, Humboldt University; Lynne Spellman, University of Arkansas;

David Stern, University of Iowa; Sean Stidd, Wayne State University; James Stuart, Bowling Green State University; Paul Studtmann, Davidson College; Krys Sulewski, Edmonds Community College; John Sullins, Sonoma State University; Weimin Sun, California State University, Northridge; Corine Sutherland, Cerritos College; Robert Sutton, Cape Fear Community College; Catherine S. Sutton, Virginia Commonwealth University; John Sweigart, James Madison University; Clarendon Swift, Moorpark College; Wayne Swindall, California Baptist College; Mojgan Taheri, California State University, Northridge; Brian Tapia, Foothill College; Bangs Tapscott, University of Utah; J. Ramon Tello, Shasta College; Mark Thames, El Centro College; Jan Thomas, University of Arkansas at Little Rock; Phil Thompson, Eastern Illinois University; Michael Thune, Joliet Junior College; Richard Tieszen, San Jose State University; Larry Udell, West Chester University; Ted Ulrich, Purdue University; Robert Urekew, University of Louisville; William Uzgalis, Oregon State University; William Vanderburgh, Wichita State University; Michael Ventimiglia, Sacred Heart University; Susan Vineberg, Wayne State University; Mark Vopat, Youngstown State University; Thomas H. Warren, Solano College; Andrew J. Waskey, Dalton State University; Roy Weatherford, University of South Florida; Chris Weigand, Our Lady of the Lake University; David Weinburger, Stockton State College; Paul Weirich, University of Missouri–Columbia; David Weise, Gonzaga University; Dennis Weiss, York College of Pennsylvania; Robert Wengert, University of Illinois at Urbana–Champaign; Shannon Grace Werre, Edmonds Community College; Gerald Joseph Williams, Seton Hall University; Derrick Willis, Temple College; Frank Wilson, Bucknell University; W. Kent Wilson, University of Illinois, Chicago; Katherine D. Witzig, Southwestern Illinois College; Sandra Woien, Mesa Community College; Stephen Wykstra, Calvin College; Julie Yoo, California State University, Northridge; Elaine Yoshikawa, Arizona State University; Marie Zaccaria, Georgia Perimeter College; Jeffrey Zents, University of Texas; Xiaoyu Zhu, Antelope Valley College.

Finally, it has been a pleasure working with the Senior Portfolio Product Manager for Philosophy, Vanessa Coloura, Senior Content Manager Michael Lepera, and Senior Learning Designer Powell Vacha. Most of all, I want to thank my wife, Linda Peterson, for her countless suggestions and support.

1 Basic Concepts

1.1 Arguments, Premises, and Conclusions

Learning how to construct good arguments is empowering. Suppose there is an upcoming election for Sheriff, and one of the candidates is Timberly Brown. One of your friends urges that you vote against Brown. "I just don't trust her," she says. "I get a bad feeling when I see her. I don't like her attitude. And I also don't like her smile or the way she dresses." Are these good reasons to vote against Brown? Has your friend given you a good argument?

Logic may be defined as the organized body of knowledge, or science, that evaluates arguments. All of us encounter arguments in our day-to-day experience. We read them in books and newspapers, hear them on television, and formulate them when communicating with friends and associates. The aim of logic is to develop a system of methods and principles that we may use as criteria for evaluating the arguments of others and as guides in constructing arguments of our own. Among the benefits to be expected from the study of logic is an increase in confidence that we are making sense when we criticize the arguments of others and when we advance arguments of our own.

1

An **argument**, in its simplest form, is a group of statements, one or more of which (the premises) are claimed to provide support for, or reasons to believe, one of the others (the conclusion). Every argument may be placed in either of two basic groups: those in which the premises really do support the conclusion and those in which they do not, even though they are claimed to. The former are said to be good arguments (at least to that extent), the latter bad arguments. The purpose of logic, as the science that evaluates arguments, is thus to develop methods and techniques that allow us to distinguish good arguments from bad.

As is apparent from the given definition, the term *argument* has a very specific meaning in logic. It does not mean, for example, a mere verbal fight, as one might have with one's parent, spouse, or friend. Let us examine the features of this definition in greater detail. First of all, an argument is a group of statements. A **statement** is a sentence that is either true or false—in other words, typically a declarative sentence or a sentence component that could stand as a declarative sentence. The following sentences are statements:

Chocolate truffles are loaded with calories.
Melatonin helps relieve jet lag.
Political candidates always tell the complete truth.
No wives ever cheat on their husbands.
Naomi Osaka plays tennis and Kevin Durant plays basketball.

The first two statements are true, and the second two false. The last one expresses two statements, both of which are true. Truth and falsity are called the two possible **truth values** of a statement. Thus, the truth value of the first two statements is true, the truth value of the second two is false, and the truth value of the last statement, as well as that of its components, is true.

Unlike statements, many sentences cannot be said to be either true or false. Questions, proposals, suggestions, commands, and exclamations usually cannot, and so are not usually classified as statements. The following sentences are not statements:

Where is Khartoum?	(question)
Let's go to a movie tonight.	(proposal)
I suggest you get contact lenses.	(suggestion)
Turn off the TV right now.	(command)
Fantastic!	(exclamation)

The statements that make up an argument are divided into one or more premises and exactly one conclusion. The **premises** are the statements that set forth the reasons or evidence, and the **conclusion** is the statement that the evidence is claimed to support or imply. In other words, the conclusion is the statement that is claimed to follow from the premises. Here is an example of an argument:

All film stars are celebrities.
Zendaya is a film star.
Therefore, Zendaya is a celebrity.

The first two statements are the premises; the third is the conclusion. (The claim that the premises support or imply the conclusion is indicated by the word "therefore.") In this argument the premises really do support the conclusion, and so the argument is a good one. But consider this argument:

Some film stars are men.
Zoe Saldana is a film star.
Therefore, Zoe Saldana is a man.

In this argument the premises do not support the conclusion, even though they are claimed to, and so the argument is not a good one.

One of the most important tasks in the analysis of arguments is being able to distinguish premises from conclusions. If what is thought to be a conclusion is really a premise, and vice versa, the subsequent analysis cannot possibly be correct. Many arguments contain indicator words that provide clues in identifying premises and conclusion. Some typical **conclusion indicators** are

therefore	accordingly	entails that
wherefore	we may conclude	hence
thus	it must be that	it follows that
consequently	for this reason	implies that
we may infer	so	as a result

Whenever a statement follows one of these indicators, it can usually be identified as the conclusion. By process of elimination, the other statements in the argument are the premises. Example:

> Tortured prisoners will say anything just to relieve the pain. Consequently, torture is not a reliable method of interrogation.

The conclusion of this argument is "Torture is not a reliable method of interrogation," and the premise is "Tortured prisoners will say anything just to relieve the pain."
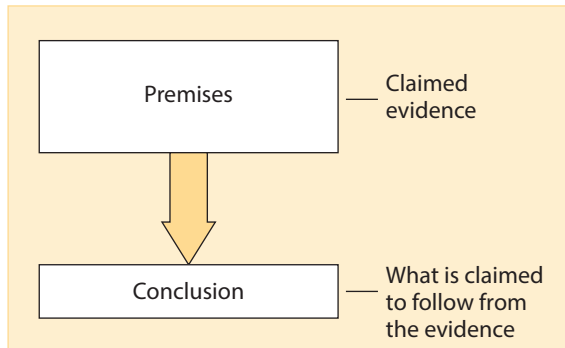
If an argument does not contain a conclusion indicator, it may contain a premise indicator. Some typical **premise indicators** are

since	as
as indicated by	given that
because	seeing that
for	for the reason that
in that	inasmuch as
may be inferred from	owing to

Any statement following one of these indicators can usually be identified as a premise. Example:

> Pregnant women should never use recreational drugs, since the use of these drugs can jeopardize the development of the fetus.

The premise of this argument is "The use of these drugs can jeopardize the development of the fetus,"

and the conclusion is "Pregnant women should never use recreational drugs."

In reviewing the list of indicators, note that "for this reason" is a conclusion indicator, whereas "for the reason that" is a premise indicator. "For this reason" (except when followed by a colon) means for the reason (premise) that was just given, so what follows is the conclusion. On the other hand, "for the reason that" announces that a premise is about to be stated.

Sometimes a single indicator can be used to identify more than one premise. Consider the following argument:

> It is vitally important that wilderness areas be preserved, for wilderness provides essential habitat for wildlife, including endangered species, and it is a natural retreat from the stress of daily life.

The premise indicator "for" goes with both "Wilderness provides essential habitat for wildlife, including endangered species," and "It is a natural retreat from the stress of daily life." These are the premises. By method of elimination, "It is vitally important that wilderness areas be preserved" is the conclusion.

Some arguments contain no indicators. With these, the reader/listener must ask such questions as: What single statement is claimed (implicitly) to follow from the others? What is the arguer trying to prove? What is the main point in the passage? The answers to these questions should point to the conclusion. Example:

> Modernizing our nation's crumbling infrastructure is long overdue. Many of our bridges are practically falling down, and our transit system is in dire ned of repair. Furthermore, making these improvements would create jobs for millions of workers.

The conclusion of this argument is the first statement, and all of the other statements are premises. The argument illustrates the pattern found in most arguments that lack indicator words: The intended conclusion is stated first, and the remaining statements are then offered in support of this first statement. When the argument is restructured according

to logical principles, however, the conclusion is always listed *after* the premises:

P₁: Many of our bridges are practically falling down.
P₂: Our transit system is in dire need of repair.
P₃: Making these improvements would create jobs for millions of workers.
C: Modernizing our nation's crumbling infrastructure is long overdue.

When restructuring arguments such as this, one should remain as close as possible to the original version, while at the same time attending to the requirement that premises and conclusion be complete sentences that are meaningful in the order in which they are listed.

Note that the first two premises are included within the scope of a single sentence in the original argument. For the purposes of this chapter, compound arrangements of statements in which the various components are all claimed to be true will be considered as separate statements.

Passages that contain arguments sometimes contain statements that are neither premises nor conclusions. Only statements that are actually intended to support the conclusion should be included in the list of premises. If, for example, a statement serves merely to introduce the general topic, or merely makes a passing comment, it should not be taken as part of the argument. Examples:

The claim is often made that malpractice lawsuits drive up the cost of health care. But if such suits were outlawed or severely restricted, then patients would have no means of recovery for injuries caused by negligent doctors. Hence, the availability of malpractice litigation should remain intact.

Massive federal deficits push up interest rates for everyone. Servicing the debt gobbles up a huge portion of the federal budget, which lowers our standard of living. And big deficits also weaken the value of the dollar. For these reasons, Congress must make a determined effort to cut overall spending and raise taxes. Politicians who ignore this reality imperil the future of the nation.

In the first argument, the opening statement serves merely to introduce the topic, so it is not part of the argument. The premise is the second statement, and the conclusion is the last statement. In the second argument, the final statement merely makes a passing comment, so it is not part of the argument. The premises are the first three statements, and the statement following "for these reasons" is the conclusion.

Closely related to the concepts of argument and statement are those of inference and proposition. An **inference**, in the narrow sense of the term, is the reasoning process expressed by an argument. In the broad sense of the term, "inference" is used interchangeably with "argument." Analogously, a **proposition**, in the narrow sense, is the meaning or information content of a statement. For the purposes of this book, however, "proposition" and "statement" are used interchangeably.

Note on the History of Logic

The person who is generally credited as the father of logic is the ancient Greek philosopher Aristotle (384–322 B.C.E.). Aristotle's predecessors had been interested in the art of constructing persuasive arguments and in techniques for refuting the arguments of others, but it was Aristotle who first devised systematic criteria for analyzing and evaluating arguments.

Aristotle's chief accomplishment is called **syllogistic logic**, a kind of logic in which the fundamental elements are *terms,* and arguments are evaluated as good or bad depending on how the terms are arranged in the argument. Chapters 4 and 5 of this textbook are devoted mainly to syllogistic logic. But Aristotle also deserves credit for originating **modal logic**, a kind of logic that involves such concepts as possibility, necessity, belief, and doubt. In addition, Aristotle catalogued several informal fallacies, a topic treated in Chapter 3 of this book.

After Aristotle's death, another Greek philosopher, Chrysippus (280–206 B.C.E.), one of the founders of the Stoic school, developed a logic in which the fundamental elements were *whole propositions.* Chrysippus treated every proposition as either true or false and developed rules for determining the truth or falsity of compound propositions from the truth or falsity of

their components. In the course of doing so, he laid the foundation for the truth-functional interpretation of the logical connectives presented in Chapter 6 of this book and introduced the notion of natural deduction, treated in Chapter 7.

For thirteen hundred years after the death of Chrysippus, relatively little creative work was done in logic. The physician Galen (c.e. 129–ca. 199) developed the theory of the compound categorical syllogism, but for the most part philosophers confined themselves to writing commentaries on the works of Aristotle and Chrysippus. Boethius (ca. 480–524) is a noteworthy example.

The first major logician of the Middle Ages was Peter Abelard (1079–1142). Abelard reconstructed and refined the logic of Aristotle and Chrysippus as communicated by Boethius, and he originated a theory of universals that traced the universal character of general terms to concepts in the mind rather than to "natures" existing outside the mind, as Aristotle had held. In addition, Abelard distinguished arguments that are valid because of their form from those that are valid because of their content, but he held that only formal validity is the "perfect" or conclusive variety. This textbook follows Abelard on this point.

After Abelard, the study of logic during the Middle Ages flourished through the work of numerous philosophers. A logical treatise by William of Sherwood (ca. 1200–1271) contains the first expression of the "Barbara, Celarent . . ." poem quoted in Section 5.1 of this book, and the *Summulae Logicales* of Peter of Spain (ca. 1205–1277) became the standard textbook in logic for three hundred years. However, the most original contributions from this period were made by William of Ockham (ca. 1285–1347). Ockham extended the theory of modal logic, conducted an exhaustive study of the forms of valid and invalid syllogisms, and further developed the idea of a metalanguage, a higher-level language used to discuss linguistic entities such as words, terms, and propositions.

Toward the middle of the fifteenth century, a reaction set in against the logic of the Middle Ages. Rhetoric largely displaced logic as the primary focus of attention; the logic of Chrysippus, which had already begun to lose its unique identity in the Middle Ages, was ignored altogether, and the logic of Aristotle was studied only in highly simplistic presentations. A reawakening did not occur until two hundred years later through the work of Gottfried Wilhelm Leibniz (1646–1716).

Leibniz, a genius in numerous fields, attempted to develop a symbolic language or "calculus" that could be used to settle all forms of disputes, whether in theology, philosophy, or international relations. As a result of this work, Leibniz is sometimes credited with being the father of symbolic logic. Leibniz's efforts to symbolize logic were carried into the nineteenth century by Bernard Bolzano (1781–1848).

In the middle of the nineteenth century, logic commenced an extremely rapid period of development that has continued to this day. Work in symbolic logic was done by many philosophers and mathematicians, including Augustus De Morgan (1806–1871), George Boole (1815–1864), William Stanley Jevons (1835–1882), and John Venn (1834–1923). The rule bearing De Morgan's name is used in Chapter 7 of this book. Boole's interpretation of categorical propositions and Venn's method for diagramming them are covered in Chapters 4 and 5. At the same time a revival in inductive logic was initiated by the British philosopher John Stuart Mill (1806–1873), whose methods of induction are presented in Chapter 10.

Across the Atlantic, the American philosopher Charles Sanders Peirce (1839–1914) developed a logic of relations, invented symbolic quantifiers, and suggested the truth-table method for formulas in propositional logic. These topics are covered in Chapters 6 and 8 of this book. The truth-table method was completed independently by Emil Post (1897–1954) and Ludwig Wittgenstein (1889–1951).

Toward the end of the nineteenth century, the foundations of modern mathematical logic were laid by Gottlob Frege (1848–1925). His *Begriffsschrift* sets forth the theory of quantification presented in Chapter 8 of this text. Frege's work was continued into the twentieth century by Alfred North Whitehead (1861–1947) and Bertrand Russell (1872–1970), whose monumental *Principia Mathematica* attempted to reduce the whole of pure mathematics to logic.

The *Principia* is the source of much of the symbolism that appears in Chapters 6, 7, and 8 of this text.

During the twentieth century, much of the work in logic focused on the formalization of logical systems and on questions dealing with the completeness and consistency of such systems. A now-famous theorem proved by Kurt Gödel (1906–1978) states that in any formal system adequate for number theory there exists an undecidable formula—that is, a formula such that neither it nor its negation is derivable from the axioms of the system. Other developments included multivalued logics and the formalization of modal logic. Most recently, logic has made a major contribution to technology by providing the conceptual foundation for the electronic circuitry of digital computers.

Exercise 1.1

I. Each of the following passages contains a single argument. Using the letters "P" and "C," identify the premises and conclusion of each argument, writing premises first and conclusion last. List the premises in the order in which they make the most sense (usually the order in which they occur), and write both premises and conclusion in the form of separate declarative sentences. Indicator words may be eliminated once premises and conclusion have been appropriately labeled. The exercises marked with a star are answered in the back of the book.

★**1.** Carbon monoxide molecules happen to be just the right size and shape, and happen to have just the right chemical properties, to fit neatly into cavities within hemoglobin molecules in blood that are normally reserved for oxygen molecules. Consequently, carbon monoxide diminishes the oxygen-carrying capacity of blood.

(Nivaldo J. Tro, *Chemistry: A Molecular Approach*, 2nd ed.)

2. Since the good, according to Plato, is that which furthers a person's real interests, it follows that in any given case when the good is known, men will seek it.

(Avrum Stroll and Richard Popkin, *Philosophy and the Human Spirit*)

3. As the denial or perversion of justice by the sentences of courts, as well as in any other manner, is with reason classed among the just causes of war, it will follow that the federal judiciary ought to have cognizance of all causes in which the citizens of other countries are concerned.

(Alexander Hamilton, *Federalist Papers*, No. 80)

★**4.** When individuals voluntarily abandon property, they forfeit any expectation of privacy in it that they might have had. Therefore, a warrantless search or seizure of abandoned property is not unreasonable under the Fourth Amendment.

(Judge Stephanie Kulp Seymour, *United States v. Jones*)

5. Artists and poets look at the world and seek relationships and order. But they translate their ideas to canvas, or to marble, or into poetic images. Scientists try to find relationships between different objects and events. To express the

order they find, they create hypotheses and theories. Thus the great scientific theories are easily compared to great art and great literature.

(Douglas C. Giancoli, *The Ideas of Physics*, 3rd ed.)

6. The fact that there was never a land bridge between Australia and mainland Asia is evidenced by the fact that the animal species in the two areas are very different. Asian placental mammals and Australian marsupial mammals have not been in contact in the last several million years.

(T. Douglas Price and Gary M. Feinman, *Images of the Past*)

★7. It really does matter if you get enough sleep. We need sleep to think clearly, react quickly, and create memories. Studies show that people who are taught mentally challenging tasks do better after a good night's sleep. Other research suggests that sleep is needed for creative problem solving.

(U.S. National Institutes of Health, "Your Guide to Healthy Sleep")

8. The classroom teacher is crucial to the development and academic success of the average student, and administrators simply are ancillary to this effort. For this reason, classroom teachers ought to be paid at least the equivalent of administrators at all levels, including the superintendent.

(Peter F. Falstrup, letter to the editor)

9. An agreement cannot bind unless both parties to the agreement know what they are doing and freely choose to do it. This implies that the seller who intends to enter a contract with a customer has a duty to disclose exactly what the customer is buying and what the terms of the sale are.

(Manuel G. Velasquez, "The Ethics of Consumer Production")

★10. Punishment, when speedy and specific, may suppress undesirable behavior, but it cannot teach or encourage desirable alternatives. Therefore, it is crucial to use positive techniques to model and reinforce appropriate behavior that the person can use in place of the unacceptable response that has to be suppressed.

(Walter Mischel and Harriet Mischel, *Essentials of Psychology*)

11. Profit serves a very crucial function in a free-enterprise economy, such as our own. High profits are the signal that consumers want more of the output of the industry. High profits provide the incentive for firms to expand output and for more firms to enter the industry in the long run. For a firm of above-average efficiency, profits represent the reward for greater efficiency.

(Dominic Salvatore, *Managerial Economics*, 3rd ed.)

12. Cats can think circles around dogs! My cat regularly used to close and lock the door to my neighbor's doghouse, trapping their sleeping Doberman inside. Try telling a cat what to do, or putting a leash on him—he'll glare at you and say, "I don't think so. You should have gotten a dog."

(Kevin Purkiser, letter to the editor)

★13. Since private property helps people define themselves, since it frees people from mundane cares of daily subsistence, and since it is finite, no individual

should accumulate so much property that others are prevented from accumulating the necessities of life.

(Leon P. Baradat, *Political Ideologies, Their Origins and Impact*)

14. To every existing thing God wills some good. Hence, since to love any thing is nothing else than to will good to that thing, it is manifest that God loves everything that exists.

(Thomas Aquinas, *Summa Theologica*)

15. Women of the working class, especially wage workers, should not have more than two children at most. The average working man can support no more and the average working woman can take care of no more in decent fashion.

(Margaret Sanger, *Family Limitations*)

★16. Radioactive fallout isn't the only concern in the aftermath of nuclear explosions. The nations of planet Earth have acquired nuclear weapons with an explosive power equal to more than a million Hiroshima bombs. Studies suggest that explosion of only half these weapons would produce enough soot, smoke, and dust to blanket the earth, block out the sun, and bring on a nuclear winter that would threaten the survival of the human race.

(John W. Hill and Doris K. Kolb, *Chemistry for Changing Times*, 7th ed.)

17. An ant releases a chemical when it dies, and its fellows then carry it away to the compost heap. Apparently the communication is highly effective; a healthy ant painted with the death chemical will be dragged to the funeral heap again and again.

(Carol R. Ember and Melvin Ember, *Cultural Anthropology*, 7th ed.)

18. Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good; and for this reason the good has rightly been declared to be that at which all things aim.

(Aristotle, *Nicomachean Ethics*)

★19. Poverty offers numerous benefits to the nonpoor. Antipoverty programs provide jobs for middle-class professionals in social work, penology, and public health. Such workers' future advancement is tied to the continued growth of bureaucracies dependent on the existence of poverty.

(J. John Palen, *Social Problems*)

20. Corn is an annual crop. Butcher's meat, a crop which requires four or five years to grow. As an acre of land, therefore, will produce a much smaller quantity of the one species of food than the other, the inferiority of the quantity must be compensated by the superiority of the price.

(Adam Smith, *The Wealth of Nations*)

21. Neither a borrower nor lender be
For loan oft loses both itself and friend,
And borrowing dulls the edge of husbandry.

(William Shakespeare, *Hamlet* I, 3)

★22. The stakes in whistleblowing are high. Take the nurse who alleges that physicians enrich themselves in her hospital through unnecessary surgery; the engineer who discloses safety defects in the braking systems of a fleet of new rapid-transit vehicles; the Defense Department official who alerts Congress to military graft and overspending: all know that they pose a threat to those whom they denounce and that their own careers may be at risk.

(Sissela Bok, "Whistleblowing and Professional Responsibility")

23. If a piece of information is not "job relevant," then the employer is not entitled qua employer to know it. Consequently, since sexual practices, political beliefs, associational activities, etc., are not part of the description of most jobs, that is, since they do not directly affect one's job performance, they are not legitimate information for an employer to know in the determination of the hiring of a job applicant.

(George G. Brenkert, "Privacy, Polygraphs, and Work")

24. Many people believe that a dark tan is attractive and a sign of good health, but mounting evidence indicates that too much sun can lead to health problems. One of the most noticeable effects is premature aging of the skin. The sun also contributes to certain types of cataracts, and, what is most worrisome, it plays a role in skin cancer.

(Joseph M. Moran and Michael D. Morgan, *Meteorology*, 4th ed.)

★25. Contrary to the tales of some scuba divers, the toothy, gaping grin on the mouth of an approaching shark is not necessarily anticipatory. It is generally accepted that by constantly swimming with its mouth open, the shark is simply avoiding suffocation. This assures a continuous flow of oxygen-laden water into their mouths, over their gills, and out through the gill slits.

(Robert A. Wallace et al., *Biology: The Science of Life*)

26. Not only is the sky blue [as a result of scattering], but light coming from it is also partially polarized. You can readily observe this by placing a piece of Polaroid (for example, one lens of a pair of Polaroid sunglasses) in front of your eye and rotating it as you look at the sky on a clear day. You will notice a change in light intensity with the orientation of the Polaroid.

(Frank J. Blatt, *Principles of Physics*, 2nd ed.)

27. Since the secondary light [from the moon] does not inherently belong to the moon and is not received from any star or from the sun, and since in the whole universe there is no other body left but the earth, what must we conclude? What is to be proposed? Surely we must assert that the lunar body (or any other dark and sunless orb) is illuminated by the earth.

(Galileo Galilei, *The Starry Messenger*)

★28. Anyone familiar with our prison system knows that there are some inmates who behave little better than brute beasts. But the very fact that these prisoners exist is a telling argument against the efficacy of capital punishment as a deterrent. If the death penalty had been truly effective as a deterrent, such prisoners would long ago have vanished.

("The Injustice of the Death Penalty," *America*)