

Integer Programming

Recall that we defined integer programming problems in our discussion of the Divisibility Assumption in Section 3.1. Simply stated, an *integer programming problem* (IP) is an LP in which some or all of the variables are required to be non-negative integers.¹

In this chapter (as for LPs in Chapter 3), we find that many real-life situations may be formulated as IPs. Unfortunately, we will also see that IPs are usually much harder to solve than LPs.

In Section 9.1, we begin with necessary definitions and some introductory comments about IPs. In Section 9.2, we explain how to formulate integer programming models. We also discuss how to solve IPs on the computer with LINDO, LINGO, and Excel Solver. In Sections 9.3–9.8, we discuss other methods used to solve IPs.

9.1 Introduction to Integer Programming

An IP in which all variables are required to be integers is called a **pure integer programming problem**. For example,

$$\begin{aligned} \max z &= 3x_1 + 2x_2 \\ \text{s.t.} \quad &x_1 + x_2 \leq 6 \\ &x_1, x_2 \geq 0, x_1, x_2 \text{ integer} \end{aligned} \tag{1}$$

is a pure integer programming problem.

An IP in which only some of the variables are required to be integers is called a **mixed integer programming problem**. For example,

$$\begin{aligned} \max z &= 3x_1 + 2x_2 \\ \text{s.t.} \quad &x_1 + x_2 \leq 6 \\ &x_1, x_2 \geq 0, x_1 \text{ integer} \end{aligned}$$

is a mixed integer programming problem (x_2 is not required to be an integer).

An integer programming problem in which all the variables must equal 0 or 1 is called a **0–1 IP**. In Section 9.2, we see that 0–1 IPs occur in surprisingly many situations.² The following is an example of a 0–1 IP:

$$\begin{aligned} \max z &= x_1 - x_2 \\ \text{s.t.} \quad &x_1 + 2x_2 \leq 2 \\ &2x_1 - x_2 \leq 1 \\ &x_1, x_2 = 0 \text{ or } 1 \end{aligned} \tag{2}$$

Solution procedures especially designed for 0–1 IPs are discussed in Section 9.7.

¹A *nonlinear integer programming problem* is an optimization problem in which either the objective function or the left-hand side of some of the constraints are nonlinear functions and some or all of the variables must be integers. Such problems may be solved with LINGO or Excel Solver.

²Actually, any pure IP can be reformulated as an equivalent 0–1 IP (Section 9.7).

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Table of Contents Chapter 9 Multicriteria Integer Linear Optimization Via

1. Understanding the eBook Chapter 9 Multicriteria Integer Linear Optimization Via
 - The Rise of Digital Reading Chapter 9 Multicriteria Integer Linear Optimization Via
 - Advantages of eBooks Over Traditional Books
2. Identifying Chapter 9 Multicriteria Integer Linear Optimization Via
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Chapter 9 Multicriteria Integer Linear Optimization Via
 - User-Friendly Interface
4. Exploring eBook Recommendations from Chapter 9 Multicriteria Integer Linear Optimization Via
 - Personalized Recommendations
 - Chapter 9 Multicriteria Integer Linear Optimization Via User Reviews and Ratings

- Chapter 9 Multicriteria Integer Linear Optimization Via and Bestseller Lists
- 5. Accessing Chapter 9 Multicriteria Integer Linear Optimization Via Free and Paid eBooks
 - Chapter 9 Multicriteria Integer Linear Optimization Via Public Domain eBooks
 - Chapter 9 Multicriteria Integer Linear Optimization Via eBook Subscription Services
 - Chapter 9 Multicriteria Integer Linear Optimization Via Budget-Friendly Options
- 6. Navigating Chapter 9 Multicriteria Integer Linear Optimization Via eBook Formats
 - ePub, PDF, MOBI, and More
 - Chapter 9 Multicriteria Integer Linear Optimization Via Compatibility with Devices
 - Chapter 9 Multicriteria Integer Linear Optimization Via Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Chapter 9 Multicriteria Integer Linear Optimization Via
 - Highlighting and Note-Taking Chapter 9 Multicriteria Integer Linear Optimization Via
 - Interactive Elements Chapter 9 Multicriteria Integer Linear Optimization Via
- 8. Staying Engaged with Chapter 9 Multicriteria Integer Linear Optimization Via
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Chapter 9 Multicriteria Integer Linear Optimization Via
- 9. Balancing eBooks and Physical Books Chapter 9 Multicriteria Integer Linear Optimization Via
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Chapter 9 Multicriteria Integer Linear Optimization Via
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Chapter 9 Multicriteria Integer Linear Optimization Via
 - Setting Reading Goals Chapter 9 Multicriteria Integer Linear Optimization Via
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Chapter 9 Multicriteria Integer Linear Optimization Via
 - Fact-Checking eBook Content of Chapter 9 Multicriteria Integer Linear Optimization Via
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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