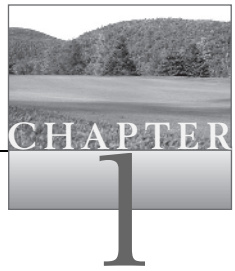

INTRODUCTION

Mathematics is the key to many of the most important aspects of golf course management. Budgeting, fertilizer and pesticide application, the ordering and application of topdressing, irrigation, and many other important parts of golf course operation require a thorough understanding of basic mathematical principles and the ability to relate those principles to real-world situations.

The purpose of this book is to offer examples of the types of mathematical problems that face golf course superintendents and to provide practical methods to solve these problems. Each chapter contains additional practice problems that can be used as a self-test to evaluate the reader's understanding of the material. Answers to the practice problems and detailed descriptions of how they are solved can be found in Appendix B.

The basics of measuring and calculating area and volume are covered in Chapters 2 and 3. While most readers will have learned these calculations in school, a review of the basics will usually be worth the time it takes to read these two chapters. Area and volume measurements are essential to nearly every aspect of golf course maintenance. A clear understanding of this information is necessary for the purchase and application of everything from pesticides to fertilizers, seed to topdressing, and in some cases even water. Practice problems are provided for readers to test their understanding of the information.

Chapters 4 and 5 provide instructions on how to solve fertilizer and pesticide problems. They provide a series of practical examples of the type that face every golf course superintendent. These chapters, like Chapters 2 and 3, have several practice problems that can be used by the reader for self-evaluation.

Chapter 6 covers calibration of the spreaders and sprayers used for the application of pesticides and fertilizers. Calibration is critical to the proper application of these materials. The chapter reviews the basic mathematical procedures necessary for calibration and provides a number of practical tips that will be useful in calibrating these machines.

The management of water resources is an important aspect of the maintenance of nearly every golf course. Mathematics is basic to every aspect of water management, from budgeting to the nightly setting of the system. Chapter 7 deals with problems that include total water use, the cost of irrigation water, and the capacity of storage lakes. As before, there are many practice problems to aid understanding of the material.

Chapter 8 concerns seed calculations. Mathematics plays an important role in determining pure live seed, the cost of seed, budgeting decisions, and application rates of seed.

Finally, Chapter 9 provides some examples of how to calculate rates of application of small amounts of materials to greenhouse pots and to small plots of the type used in research studies. While this information is provided for graduate students involved in university research, it may also be of use to the superintendent who wants to conduct on-course research involving small test areas.

PROPORTIONS

The goal of this book is to teach practical mathematics and to show how it applies to the golf course industry. In addition, we would like to teach the reader a different way of looking at mathematics. Rather than just putting numbers into a calculator and obtaining a result, we will concentrate on the thought process and the logic that goes into the calculations. We will then deal with the mechanics of getting the final answer.

Each chapter will rely on the use of mathematical proportions combined with a logical, methodical way of looking at the problems.

For example, let's say that we know that the application rate for a pesticide is four ounces per one thousand square feet (4 oz/1,000 ft^2) and that we need to treat a total of 21,000 ft^2. How much material is needed for the 21,000 ft^2 area?

We will begin with what we know and then use logic to set up a simple mathematical relationship to provide the answer. In this case, we know that the application rate is 4 oz /1,000 ft^2. The process begins by asking the right question. That question in this case is, ''If 4 oz are to be applied on 1,000 ft^2, then how much should be applied to 21,000 ft^2?'' The problem is set up mathematically as follows:

$$\frac{4\text{ oz}}{1,000\text{ ft}^2} = \frac{\text{X oz}}{21,000\text{ ft}^2}$$

This is called a **proportion**. It is a common technique used in mathematics to find unknown values. In this case, the X is the unknown. The X could just as easily be a question mark (?). Throughout the book, we will use an X whenever we want to determine some unknown amount of material. Again, the words that should be formed in the reader's mind as the proportion is written are as follows: ''If 4 oz are to be applied to 1,000 ft^2, then how many ounces (X) should be applied to 21,000 ft^2?''

A proportion is solved by cross-multiplying and dividing. Begin by multiplying across the equation as shown below.

$$\frac{4\text{ oz}}{1{,}000\text{ ft}^2} \times \frac{X\text{ oz}}{21{,}000\text{ ft}^2}$$

$$1{,}000X = (4)(21{,}000)$$

$$1{,}000X = 84{,}000$$

This step tells us what 1,000 times the desired amount is. To find the exact amount X requires one more step. Next, divide both sides by the amount with the X on the left side of the equation, in this case 1,000. This step removes the 1,000 from the left side of the equation and leaves us with X, the exact amount that is needed for the application.

$$\frac{1{,}000X}{1{,}000} = \frac{84{,}000}{1{,}000}$$

$$X = 84\text{ oz}$$

We now know that X is 84 oz, and the answer to the question is that 84 oz of product needs to be applied to 21,000 ft^2 to achieve an application rate of 4 oz/1,000 ft^2.

This procedure will be used repeatedly throughout the book to solve a wide variety of problems. For a more detailed description of this process, see Chapter 4.

ACCURACY AND PRECISION

The terms **accuracy** and **precision** often come up when applying fertilizers and pesticides. Accuracy refers to how close a measured value comes to the real value. For example, it is important to measure accurately how many pounds of fertilizer are to be applied to a given area. If the desired rate is 1 lb nitrogen (N)/1,000 ft^2 and the calculations are off by 10% because of an error, there is an inaccuracy and a new calculation is needed. On the golf course, there are times when the superintendent's job depends on accuracy.

Precision refers to how close multiple measurements come to one another. Precision occurs when the spreader or sprayer is properly calibrated and the same amount of material is applied in each application.

SIGNIFICANT DIGITS AND ROUNDING

Rounding is often necessary when working math problems. When rounding, it is important to determine the level of significance. If the answer to a problem is that 34.245 lb N needs to be applied to a green, it is safe to round that number to

34 lb. In this example, it is fine to round to the nearest whole number of 34 lb, because fertilizer spreaders are not capable of achieving accuracy of less than 1 lb. A frequent question is when rounding should take place in a multistep problem. It is generally recommended that you carry one or two more decimal places than are needed as the multiple steps are worked and then use rounding when the final answer has been reached.

It is possible to round too far. For instance, the area of an acre, 43,560 ft^2, should not be rounded to 44,000 ft^2. This could result in significant errors, particularly on a long multistep problem.

The rules listed below will be followed when rounding numbers in this book.

1. When rounding a number that is less than 1 start counting with the first nonzero number. For example, 0.0042051 would be rounded to 0.0042.
2. If the number to the right of the last significant digit is less than 5, drop this digit and all the digits to the right of it. For example, round 131.2334 to 131.2. This is called rounding down.
3. If the number to the right of the last significant digit is 5 or greater, increase the last significant digit by one and drop all of the digits to the right of it. For example, round 131.2633 to 131.3. This is called rounding up.

UNITS OF MEASURE

Since golf is a global industry, both the English system of measurement (also known as the United States customary system) and the metric system are presented in the text.

The United States uses the English system, and we will emphasize this system in the text. We will also provide examples in the metric system in each chapter for those who use this system on the golf course.

The English system uses units such as the acre (ac), pound (lb), ounce (oz), foot (ft), and inch (in.). There are 12 in. in a foot, 3 ft in a yard, and 5,280 ft in a mile. All of the standard units of measure in the English system are presented in Appendix A.

The metric system uses units such as the millimeter (mm), centimeter (cm), meter (m), hectare (ha), and liter (L) (see Appendix A for a more complete list). This system differs from the English system in that everything is based on a factor of 10. There are 10 mm in a centimeter, 100 cm in a meter, and 1,000 m in a kilometer (km). Mathematical problems are generally easier in the metric system than in the English system because of the ease of dealing with factors of 10.

For many readers, the principles presented in the following chapter will be new. If that is the case, take things slowly. Begin by carefully reading each chapter and working the sample problems. Once a level of confidence is reached, go to practical examples on the golf course. Measure the area of greens, tees, and fairways. Then do some calculations on products actually used on the course.

Finally, the best way to learn mathematics is to teach it to someone else. Once you are comfortable with the material, try teaching it to crew members and other employees. Not only will they benefit from the information, but also you will find the experience a valuable way to learn.