EDITION 9

FINITE MATHEMATICS

FOR THE MANAGERIAL, LIFE, AND SOCIAL SCIENCES

S. T. TAN
STONEHILL COLLEGE

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Finite Mathematics for the Managerial, Life, and Social Sciences, Ninth Edition
S. T. Tan

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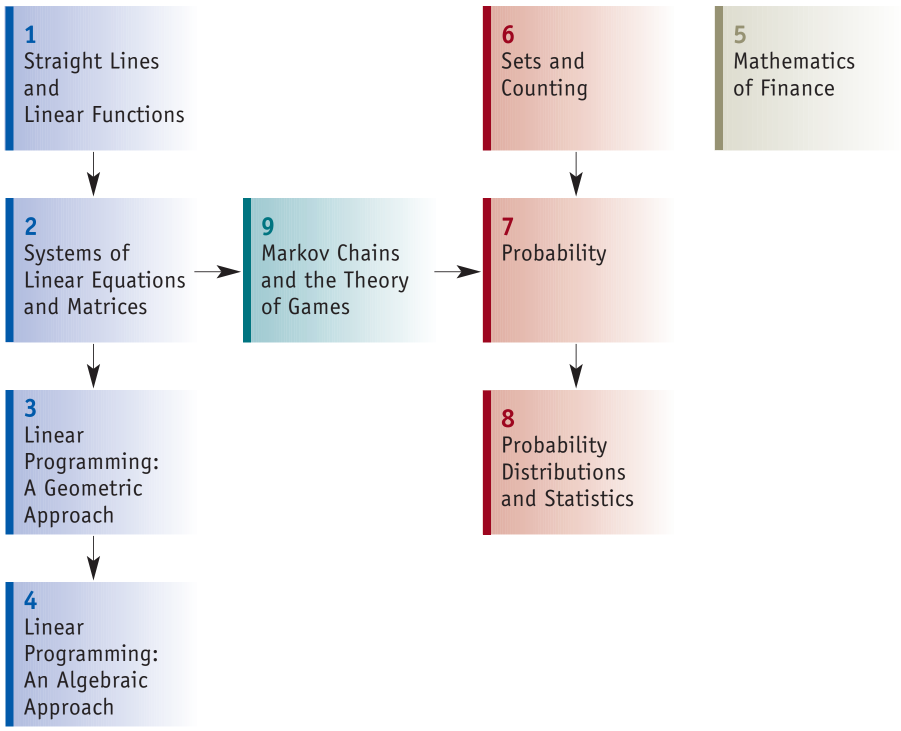
CONTENTS

PREFACE

Math is an integral part of our increasingly complex daily life. *Finite Mathematics for the Managerial, Life, and Social Sciences, Ninth Edition,* attempts to illustrate this point with its applied approach to mathematics. Our objective for this Ninth Edition is threefold: (1) to write an applied text that motivates students while providing the background in the quantitative techniques necessary to better understand and appreciate the courses normally taken in undergraduate training, (2) to lay the foundation for more advanced courses, such as statistics and operations research, and (3) to make the text a useful tool for instructors. The only prerequisite for understanding this text is 1 to 2 years, or the equivalent, of high school algebra.

This text offers more than enough material for a one-semester or two-quarter course. The following chart on chapter dependency is provided to help the instructor design a course that is most suitable for the intended audience.



THE APPROACH

Level of Presentation

My approach is intuitive, and I state the results informally. However, I have taken special care to ensure that this approach does not compromise the mathematical content and accuracy.

Problem-Solving Approach

A problem-solving approach is stressed throughout the book. Numerous examples and applications illustrate each new concept and result. Special emphasis is placed on helping students formulate, solve, and interpret the results of the problems involving applications. Graphs and illustrations are used extensively to help students visualize the concepts and ideas being presented.

NEW TO THIS EDITION

Motivating Real-World Applications

More than 90 new applications have been added. Among these applications are U.S. health-care expenditures, satellite TV subscribers, worldwide consulting spending, investment portfolios, adjustable-rate mortgages, green companies, security breaches, distracted drivers, obesity in children, and water supply.

APPLIED EXAMPLE 5 Adjustable Rate Mortgages Five years ago, the Campbells secured a 5/1 ARM to help finance the purchase of their home. The amount of the original loan was $350,000 for a term of 30 years, with interest at the rate of 5.76% per year, compounded monthly. The Campbells' mortgage is due to reset next month and the new interest rate will be 6.96% per year, compounded monthly.

a. What was the Campbells' monthly mortgage payment for the first 5 years?

b. What will the Campbells' new monthly mortgage payment be (after the reset)? By how much will the monthly payment increase?

Solution

a. First, we find the Campbells' monthly payment on the original loan amount. Using Formula (13) with $P = 350{,}000$, $i = \frac{r}{m} = \frac{0.0576}{12}$, and $n = mt = (12)(30) = 360$, we find that the monthly payment was

$$R = \frac{350{,}000\left(\frac{0.0576}{12}\right)}{1 - \left(1 + \frac{0.0576}{12}\right)^{-360}} \approx 2044.729$$

or $2044.73 for the first 5 years.

Modeling with Data

Students can actually see how some of the functions found in the examples and exercises are constructed. (See Applied Example 1, U.S. Health-Care Expenditures, page 29, and the corresponding example from which the model is derived in Applied Example 3, page 55.) Modeling with Data exercises are now found in Using Technology, Section 1.5.

APPLIED EXAMPLE 1 U.S. Health-Care Expenditures Because the over-65 population will be growing more rapidly in the next few decades, health-care spending is expected to increase significantly in the coming decades. The following table gives the projected U.S. health-care expenditure (in trillions of dollars) from 2005 through 2010 (the figures after 2006 are estimates):

Year	2005	2006	2007	2008	2009	2010

APPLIED EXAMPLE 3 U.S. Health-Care Expenditures Refer to Example 1 of Section 1.3. Because the over-65 population will be growing more rapidly in the next few decades, health-care spending is expected to increase significantly in the coming decades. The following table gives the U.S. health expenditures (in trillions of dollars) from 2005 through 2010, where t is measured in years, with $t = 0$ corresponding to 2005.

Year, t	0	1	2	3	4	5
Expenditure, y	2.00	2.17	2.34	2.50	2.69	2.90

(The figures after 2006 are estimates.) Find a function giving the U.S. health-care spending between 2005 and 2010, using the least-squares technique.

Making Connections with Technology

A new example—Market for Cholesterol-Reducing Drugs—has been added to Using Technology 1.3. Also, Exploring with Technology examples illustrating the use of the graphing calculator to solve inequalities, to generate random numbers, and to find the area under the standard normal curve have been added.

USING TECHNOLOGY

APPLIED EXAMPLE 4 Market for Cholesterol-Reducing Drugs In a study conducted in early 2000, experts projected a rise in the market for cholesterol-reducing drugs. The U.S. market (in billions of dollars) for such drugs from 1999 through 2004 is approximated by

$$M(t) = 1.95t + 12.19$$

where t is measured in years, with $t = 0$ corresponding to 1999.

a. Plot the graph of the function M over the interval $[0, 6]$.
b. Assuming that the projection held and the trend continued, what was the market for cholesterol-reducing drugs in 2005 ($t = 6$)?
c. What was the rate of increase of the market for cholesterol-reducing drugs over the period in question?

Source: S. G. Cowen

Using Logarithms to Solve Problems in Finance—New Optional Examples and Exercises

This new subsection has been added to Chapter 5, Mathematics of Finance. Examples and exercises in which the rate of interest is solved for, or the time needed to meet an investment goal is found, are now covered here.

EXAMPLE 11 How long will it take \$10,000 to grow to \$15,000 if the investment earns an interest rate of 12% per year compounded quarterly?

Solution Using Formula (3) with $A = 15{,}000$, $P = 10{,}000$, $r = 0.12$, and $m = 4$, we obtain

$$15{,}000 = 10{,}000\left(1 + \frac{0.12}{4}\right)^{4t}$$

$$(1.03)^{4t} = \frac{15{,}000}{10{,}000} = 1.5$$

Taking the logarithm on each side of the equation gives

$$\ln(1.03)^{4t} = \ln 1.5$$

$$4t \ln 1.03 = \ln 1.5 \qquad \log_b m^n = n \log_b m$$

$$4t = \frac{\ln 1.5}{\ln 1.03}$$

So it
$15,(

EXAMPLE 12 Find the interest rate needed for an investment of \$10,000 to grow to an amount of \$18,000 in 5 years if the interest is compounded monthly.

Solution Use Formula (3) with $A = 18{,}000$, $P = 10{,}000$, $m = 12$, and $t = 5$. Thus $i = \frac{r}{12}$ and $n = (12)(5) = 60$, so

$$18{,}000 = 10{,}000\left(1 + \frac{r}{12}\right)^{12(5)}$$

Dividing both sides of the equation by 10,000 gives

$$\frac{18{,}000}{10{,}000} = \left(1 + \frac{r}{12}\right)^{60}$$

or, upon simplification,

$$\left(1 + \frac{r}{12}\right)^{60} = 1.8$$

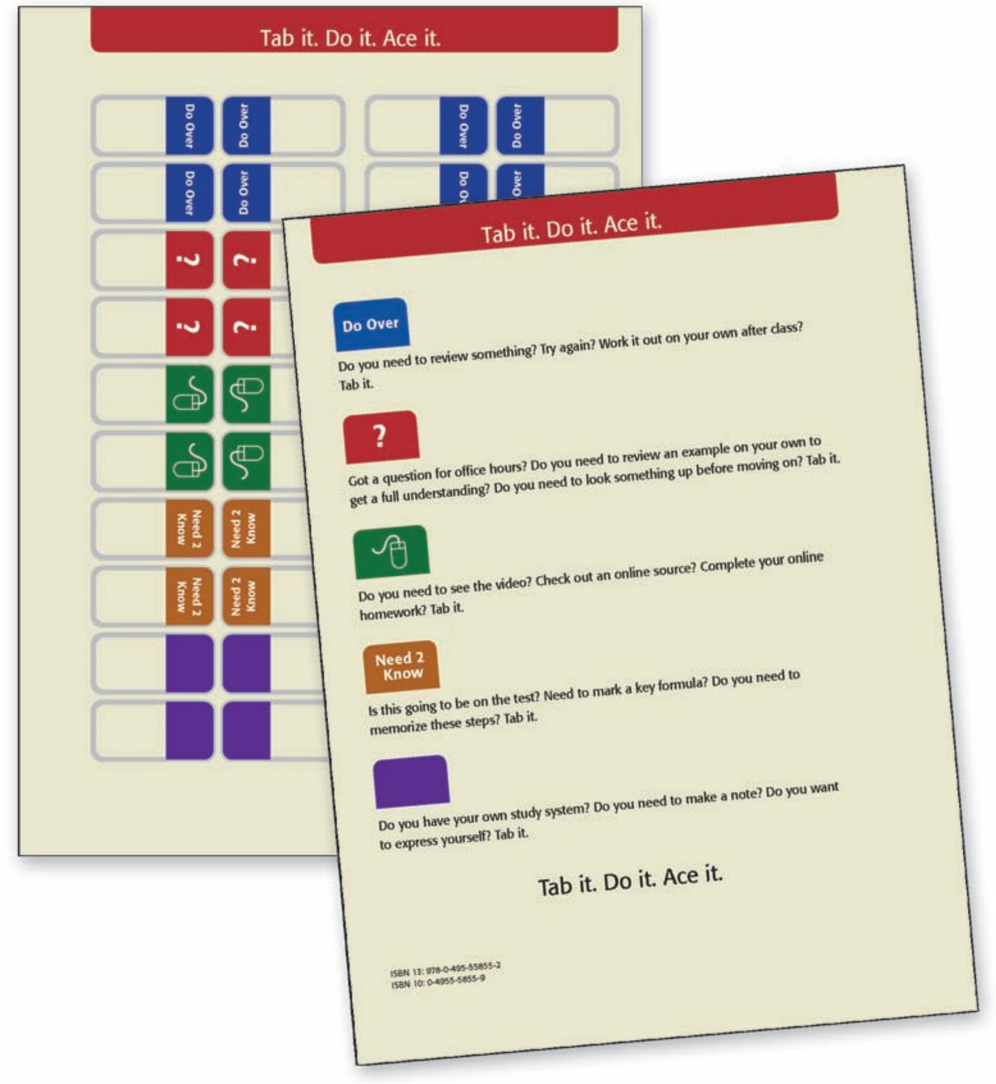
Now, we take the logarithm on each side of the equation, obtaining

$$\ln\left(1 + \frac{r}{12}\right)^{60} = \ln 1.8$$

$$60 \ln\left(1 + \frac{r}{12}\right) = \ln 1.8$$

Action-Oriented Study Tabs

Convenient color-coded study tabs, similar to Post-it® flags, make it easy for students to tab pages that they want to return to later, whether it be for additional review, exam preparation, online exploration, or identifying a topic to be discussed with the instructor.



Specific Content Changes

- A new mathematical model, U.S. health-care expenditures, is discussed in Section 1.3. In Section 1.5, the linear function used in the model is derived using the least-squares method.
- The discussion of mortgages has been enhanced with a new example on adjustable-rate mortgages and the addition of many new applied exercises.
- More rote and applied exercises have been added to the chapter reviews.
- Appendix A, on Logic, has been revised.
- A Review of Logarithms is now found in Appendix C. This material supplements the optional subsection on Using Logarithms to Solve Problems in Finance in Chapter 5.
- A How-To Technology Index has been added for easy reference.
- The complete solutions to the exercises in Appendix A, Logic, have been added to the *Instructor's Solutions Manual*, and the odd-numbered solutions for these exercises have been added to the *Student Solutions Manual*.
- New Using Technology Excel sections for Microsoft Office 2007 will now be available on the Web.

TRUSTED FEATURES

In addition to the new features, we have retained many of the following hallmarks that have made this series so usable and well-received in past editions:

- Section exercises to help students understand and apply concepts
- Optional technology sections to explore mathematical ideas and solve problems
- End-of-chapter review sections to assess understanding and problem-solving skills
- Features to motivate further exploration

Self-Check Exercises

Offering students immediate feedback on key concepts, these exercises begin each end of section exercise set. Fully worked-out solutions can be found at the end of each exercise section.

2.2 Self-Check Exercises

1. Solve the system of linear equations

$$\begin{aligned} 2x + 3y + z &= 6 \\ x - 2y + 3z &= -3 \\ 3x + 2y - 4z &= 12 \end{aligned}$$

using the Gauss–Jordan elimination method.

2. A farmer has 200 acres of land suitable for cultivating crops A, B, and C. The cost per acre of cultivating crop A, crop B, and crop C is \$40, \$60, and \$80, respectively. The farmer has \$12,600 available for land cultivation. Each acre of crop A requires 20 labor-hours, each acre of crop B requires 25 labor-hours, and each acre of crop C requires 40 labor-hours. The farmer has a maximum of 5950 labor-hours available. If she wishes to use all of her cultivatable land, the entire budget, and all the labor available, how many acres of each crop should she plant?

Solutions to Self-Check Exercises 2.2 can be found on page 89.

Concept Questions

Designed to test students' understanding of the basic concepts discussed in the section, these questions encourage students to explain learned concepts in their own words.

2.2 Concept Questions

1. a. Explain what it means for two systems of linear equations to be equivalent to each other.
   b. Give the meaning of the following notation used for row operations in the Gauss–Jordan elimination method:
   i. $R_i \leftrightarrow R_j$ ii. cR_i iii. $R_i + aR_j$
2. a. What is an augmented matrix? A coefficient matrix? A unit column?
   b. Explain what is meant by a pivot operation.
3. Suppose that a matrix is in row-reduced form.
   a. What is the position of a row consisting entirely of zeros relative to the nonzero rows?
   b. What is the first nonzero entry in each row?
   c. What is the position of the leading 1s in successive nonzero rows?
   d. If a column contains a leading 1, then what is the value of the other entries in that column?

Exercises

Each exercise section contains an ample set of problems of a routine computational nature followed by an extensive set of application-oriented problems.

2.2 Exercises

In Exercises 1–4, write the augmented matrix corresponding to each system of equations.

1. $\begin{aligned} 2x - 3y &= 7 \\ 3x + y &= 4 \end{aligned}$

2. $\begin{aligned} 3x + 7y - 8z &= 5 \\ x + 3z &= -2 \\ 4x - 3y &= 7 \end{aligned}$

3. $\begin{aligned} -y + 2z &= 6 \\ 2x + 2y - 8z &= 7 \\ 3y + 4z &= 0 \end{aligned}$

4. $\begin{aligned} 3x_1 + 2x_2 &= 0 \\ x_1 - x_2 + 2x_3 &= 4 \\ 2x_2 - 3x_3 &= 5 \end{aligned}$

In Exercises 5–8, write the system of equations corresponding to each augmented matrix.

5. $\left[\begin{array}{cc|c} 3 & 2 & -4 \\ 1 & -1 & 5 \end{array}\right]$

23. $\left[\begin{array}{ccc|c} 2 & 4 & 6 & 12 \\ 2 & 3 & 1 & 5 \\ 3 & -1 & 2 & 4 \end{array}\right]$

24. $\left[\begin{array}{ccc|c} 1 & 3 & 2 & 4 \\ 2 & 4 & 8 & 6 \\ -1 & 2 & 3 & 4 \end{array}\right]$

25. $\left[\begin{array}{ccc|c} 0 & 1 & 3 & 4 \\ 2 & 4 & 1 & 3 \\ 5 & 6 & 2 & -4 \end{array}\right]$

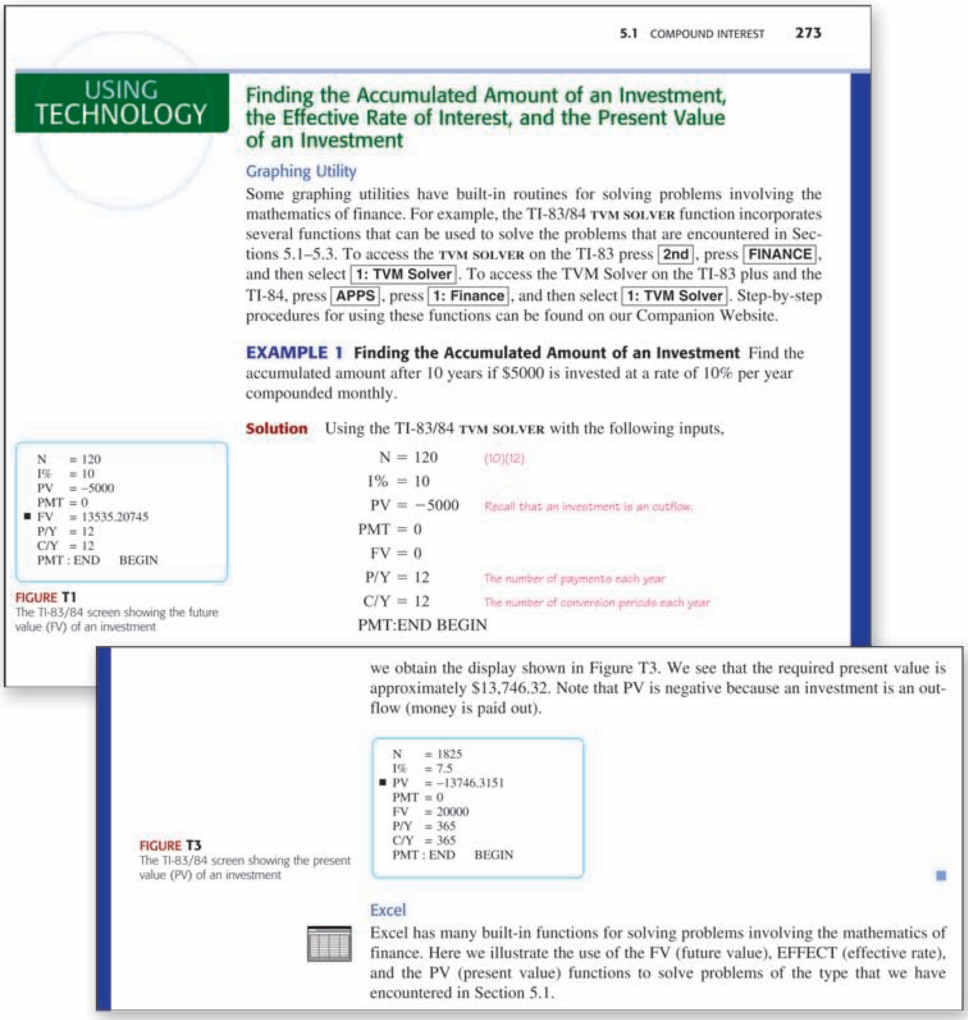
26. $\left[\begin{array}{ccc|c} 1 & 2 & 3 & 5 \\ 0 & -3 & 3 & 2 \\ 0 & 4 & -1 & 3 \end{array}\right]$

In Exercises 27–30, fill in the missing entries by performing the indicated row operations to obtain the row-reduced matrices.

27. $\left[\begin{array}{cc|c} 3 & 9 & 6 \\ 2 & 1 & 4 \end{array}\right] \xrightarrow{\frac{1}{3}R_1} \left[\begin{array}{cc|c} \cdot & \cdot & \cdot \\ 2 & 1 & 4 \end{array}\right] \xrightarrow{R_2 - 2R_1}$

Using Technology

These optional subsections appear after the section exercises. They can be used in the classroom if desired or as material for self-study by the student. Here, the graphing calculator and Microsoft Excel 2003 are used as a tool to solve problems. (Instructions for Microsoft Excel 2007 are given at the Companion Website.) These sections are written in the traditional example–exercise format, with answers given at the back of the book. Illustrations showing graphing calculator screens and spreadsheets are extensively used. In keeping with the theme of motivation through real-life examples, many sourced applications are again included. Students can construct their own models using real-life data in Using Technology Section 1.5.



5.1 COMPOUND INTEREST 273

USING TECHNOLOGY

Finding the Accumulated Amount of an Investment, the Effective Rate of Interest, and the Present Value of an Investment

Graphing Utility

Some graphing utilities have built-in routines for solving problems involving the mathematics of finance. For example, the TI-83/84 TVM SOLVER function incorporates several functions that can be used to solve the problems that are encountered in Sections 5.1–5.3. To access the TVM SOLVER on the TI-83 press 2nd, press FINANCE, and then select 1: TVM Solver. To access the TVM Solver on the TI-83 plus and the TI-84, press APPS, press 1: Finance, and then select 1: TVM Solver. Step-by-step procedures for using these functions can be found on our Companion Website.

EXAMPLE 1 Finding the Accumulated Amount of an Investment Find the accumulated amount after 10 years if \$5000 is invested at a rate of 10% per year compounded monthly.

Solution Using the TI-83/84 TVM SOLVER with the following inputs,

N = 120 (10)(12)
I% = 10
PV = −5000 Recall that an investment is an outflow.
PMT = 0
FV = 0
P/Y = 12 The number of payments each year
C/Y = 12 The number of conversion periods each year
PMT:END BEGIN

N = 120
I% = 10
PV = −5000
PMT = 0
■ FV = 13535.20745
P/Y = 12
C/Y = 12
PMT : END BEGIN

FIGURE T1
The TI-83/84 screen showing the future value (FV) of an investment

we obtain the display shown in Figure T3. We see that the required present value is approximately \$13,746.32. Note that PV is negative because an investment is an outflow (money is paid out).

N = 1825
I% = 7.5
■ PV = −13746.3151
PMT = 0
FV = 20000
P/Y = 365
C/Y = 365
PMT : END BEGIN

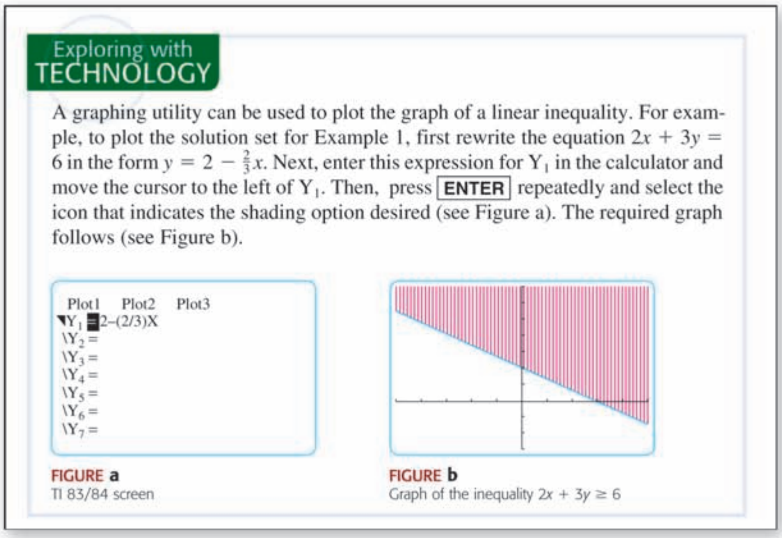
FIGURE T3
The TI-83/84 screen showing the present value (PV) of an investment

Excel

Excel has many built-in functions for solving problems involving the mathematics of finance. Here we illustrate the use of the FV (future value), EFFECT (effective rate), and the PV (present value) functions to solve problems of the type that we have encountered in Section 5.1.

Exploring with Technology

Designed to explore mathematical concepts and to shed further light on examples in the text, these optional discussions appear throughout the main body of the text and serve to enhance the student's understanding of the concepts and theory presented. Often the solution of an example in the text is augmented with a graphical or numerical solution. Complete solutions to any questions posed are given in the *Instructor's Solutions Manual*.



Exploring with TECHNOLOGY

A graphing utility can be used to plot the graph of a linear inequality. For example, to plot the solution set for Example 1, first rewrite the equation $2x + 3y = 6$ in the form $y = 2 - \frac{2}{3}x$. Next, enter this expression for Y_1 in the calculator and move the cursor to the left of Y_1. Then, press ENTER repeatedly and select the icon that indicates the shading option desired (see Figure a). The required graph follows (see Figure b).

Plot1 Plot2 Plot3
Y_1 = 2−(2/3)X
Y_2 =
Y_3 =
Y_4 =
Y_5 =
Y_6 =
Y_7 =

FIGURE a
TI 83/84 screen

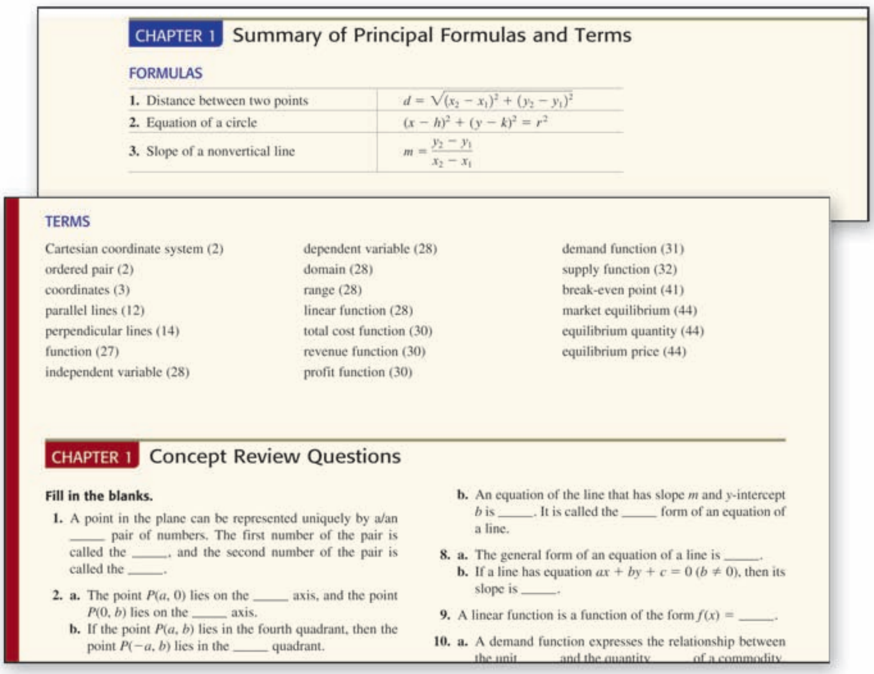
FIGURE b
Graph of the inequality $2x + 3y \geq 6$

Summary of Principal Formulas and Terms

Each review section begins with the Summary highlighting important equations and terms with page numbers given for quick review.

Concept Review Questions

These questions give students a chance to check their knowledge of the basic definitions and concepts given in each chapter.



CHAPTER 1 Summary of Principal Formulas and Terms

FORMULAS

1. Distance between two points	$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
2. Equation of a circle	$(x - h)^2 + (y - k)^2 = r^2$
3. Slope of a nonvertical line	$m = \dfrac{y_2 - y_1}{x_2 - x_1}$

TERMS

Cartesian coordinate system (2)	dependent variable (28)	demand function (31)
ordered pair (2)	domain (28)	supply function (32)
coordinates (3)	range (28)	break-even point (41)
parallel lines (12)	linear function (28)	market equilibrium (44)
perpendicular lines (14)	total cost function (30)	equilibrium quantity (44)
function (27)	revenue function (30)	equilibrium price (44)
independent variable (28)	profit function (30)	

CHAPTER 1 Concept Review Questions

Fill in the blanks.

1. A point in the plane can be represented uniquely by a/an _____ pair of numbers. The first number of the pair is called the _____, and the second number of the pair is called the _____.
2. a. The point $P(a, 0)$ lies on the _____ axis, and the point $P(0, b)$ lies on the _____ axis.
   b. If the point $P(a, b)$ lies in the fourth quadrant, then the point $P(-a, b)$ lies in the _____ quadrant.

b. An equation of the line that has slope m and y-intercept b is _____. It is called the _____ form of an equation of a line.

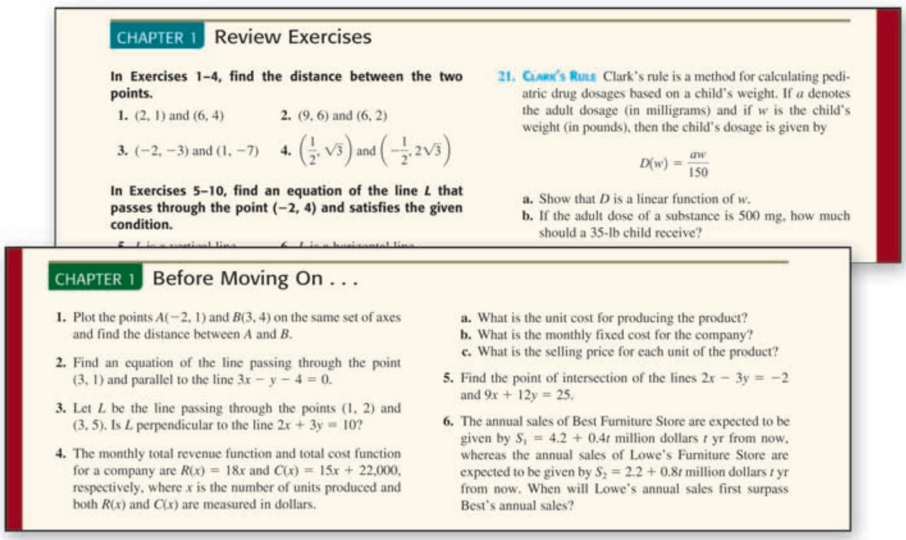
8. a. The general form of an equation of a line is _____.
   b. If a line has equation $ax + by + c = 0$ ($b \neq 0$), then its slope is _____.
9. A linear function is a function of the form $f(x) =$ _____.
10. a. A demand function expresses the relationship between the unit _____ and the quantity _____ of a commodity

Review Exercises

Offering a solid review of the chapter material, the Review Exercises contain routine computational exercises followed by applied problems.

Before Moving On . . .

Found at the end of each chapter review, these exercises give students a chance to see if they have mastered the basic computational skills developed in each chapter. If they solve a problem incorrectly, they can go to the Companion Website and try again. In fact, they can keep on trying until they get it right. If students need step-by-step help, they can use the *CengageNOW Tutorials* that are keyed to the text and work out similar problems at their own pace.



CHAPTER 1 Review Exercises

In Exercises 1–4, find the distance between the two points.

1. (2, 1) and (6, 4)
2. (9, 6) and (6, 2)
3. (−2, −3) and (1, −7)
4. $\left(\frac{1}{2}, \sqrt{3}\right)$ and $\left(-\frac{1}{2}, 2\sqrt{3}\right)$

In Exercises 5–10, find an equation of the line L that passes through the point (−2, 4) and satisfies the given condition.

5. L is a vertical line. 6. L is a horizontal line.

21. CLARK'S RULE Clark's rule is a method for calculating pediatric drug dosages based on a child's weight. If a denotes the adult dosage (in milligrams) and if w is the child's weight (in pounds), then the child's dosage is given by

$$D(w) = \frac{aw}{150}$$

a. Show that D is a linear function of w.
b. If the adult dose of a substance is 500 mg, how much should a 35-lb child receive?

CHAPTER 1 Before Moving On . . .

1. Plot the points $A(-2, 1)$ and $B(3, 4)$ on the same set of axes and find the distance between A and B.
2. Find an equation of the line passing through the point (3, 1) and parallel to the line $3x - y - 4 = 0$.
3. Let L be the line passing through the points (1, 2) and (3, 5). Is L perpendicular to the line $2x + 3y = 10$?
4. The monthly total revenue function and total cost function for a company are $R(x) = 18x$ and $C(x) = 15x + 22{,}000$, respectively, where x is the number of units produced and both $R(x)$ and $C(x)$ are measured in dollars.
   a. What is the unit cost for producing the product?
   b. What is the monthly fixed cost for the company?
   c. What is the selling price for each unit of the product?
5. Find the point of intersection of the lines $2x - 3y = -2$ and $9x + 12y = 25$.
6. The annual sales of Best Furniture Store are expected to be given by $S_1 = 4.2 + 0.4t$ million dollars t yr from now, whereas the annual sales of Lowe's Furniture Store are expected to be given by $S_2 = 2.2 + 0.8t$ million dollars t yr from now. When will Lowe's annual sales first surpass Best's annual sales?

Explore & Discuss

These optional questions can be discussed in class or assigned as homework. These questions generally require more thought and effort than the usual exercises. They may also be used to add a writing component to the class or as team projects. Complete solutions to these exercises are given in the *Instructor's Solutions Manual.*

Explore & Discuss

Future Value S of an Annuity Due

1. Consider an annuity satisfying conditions 1, 2, and 4 on page 276 but with condition 3 replaced by the condition that payments are made at the *beginning* of the payment periods. By using an argument similar to that used to establish Formula (9), show that the future value S of an annuity due of n payments of R dollars each, paid at the beginning of each investment into an account that earns interest at the rate of i per period, is

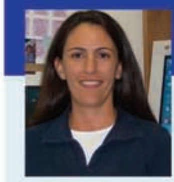
$$S = R(1 + i)\left[\frac{(1 + i)^n - 1}{i}\right]$$

2. Use the result of part 1 to see how large your nest egg will be at age 65 if you start saving $4000 annually at age 30, assuming a 10% average annual return; if you start saving at 35; if you start saving at 40. [Moral of the story: It is never too early to start saving!]

Portfolios

The real-life experiences of a variety of professionals who use mathematics in the workplace are related in these interviews. Among those interviewed are a senior account manager at PepsiCo and an associate on Wall Street who uses statistics and calculus in writing options.

PORTFOLIO Stephanie Molina



TITLE Computer Crimes Detective
INSTITUTION Maricopa County Sheriff's Office

Working as a detective in the computer crimes division of the Maricopa County Sheriff's Office, I find applied mathematics techniques play a significant role in my job when I search for evidence contained on computer hard drives and other forms of media. To obtain evidence, I am required to have a working knowledge of certain applied mathematics skills so that I can effectively communicate with the computer forensic analyst who will be decoding the evidence. To conduct an effective investigation, I am also required to understand these data in a wide variety of formats. With this information, I can work with the analyst to reconstruct data that may play a significant roll in determining events that occurred pertaining to a crime.

During the course of an investigation, I have to look at the data not only in text but also in code. Using this view, the analyst can decipher different file types and possible evidence in unallocated space throughout the hard drive. This unallocated space can contain deleted files that may contain potential evidence. The analyst also has to decode files by hand, and at this point, recognizing patterns among the files becomes very important. From here, we can derive an algorithm to define those patterns. By producing an algorithm, it makes it possible to write a program that will decode the files.

For example, there was a case that involved a suspect who was receiving files through a mail server. This suspect was then opening the files and deleting the email. Members of my computer forensic laboratory and I viewed these files in their original code to try to discover any patterns or inconsistencies within the code to find a solution to the problem. We did find a clue buried within the code. We then derived an algorithm defining its pattern. By inputting the algorithm, we could then extract the files from the coded data.

Although I do not have a solid background in computer science or even mathematics, my knowledge of applied mathematics helps me understand the procedures involved in obtaining evidence. Best of all, I am able to clearly convey my needs to the forensic analysts in my department.

Example Videos

Available through the Online Resource Center and Enhanced WebAssign, these video examples offer hours of instruction from award-winning teacher Deborah Upton of Stonehill College. Watch as she walks students through key examples from the text, step by step—giving them a foundation in the skills that they need to know. Each example available online is identified by the video icon located in the margin.

VIDEO

APPLIED EXAMPLE 7 Market Equilibrium The quantity demanded of a certain model of DVD player is 8000 units when the unit price is $260. At a unit price of $200, the quantity demanded increases to 10,000 units. The manufacturer will not market any players if the price is $100 or lower. However, for each $50 increase in the unit price above $100, the manufacturer will market an additional 1000 units. Both the demand and the supply equations are known to be linear.

a. Find the demand equation.
b. Find the supply equation.
c. Find the equilibrium quantity and price.

TEACHING AIDS

INSTRUCTOR'S SOLUTIONS MANUAL (ISBN 0-495-38897-1) by Soo T. Tan
The complete solutions manual provides worked out solutions to all problems in the text, as well as "Exploring with Technology" and "Explore & Discuss" questions.

POWERLECTURE (ISBN 0-495-38899-8)
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