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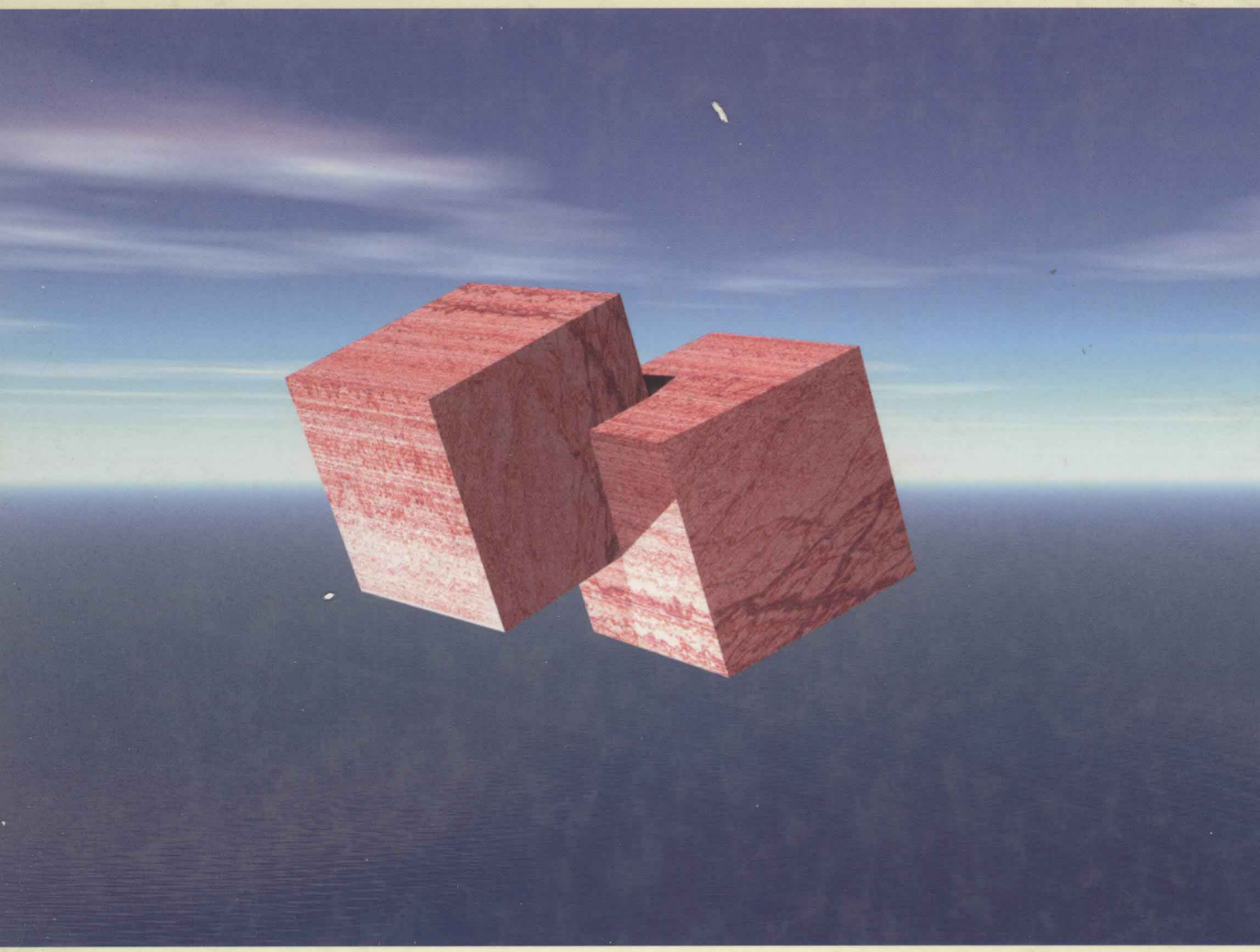
For Business, Economics, Life Sciences, and Social Sciences

Ninth Edition



Raymond A. Barnett / Michael R. Ziegler / Karl E. Byleen

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FOR BUSINESS, ECONOMICS, LIFE SCIENCES, AND SOCIAL SCIENCES

Ninth Edition

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PRENTICE HALL
Upper Saddle River, New Jersey 07458

Library of Congress Cataloging-in-Publication Data

Barnett, Raymond A.
College mathematics for business, economics, life sciences, and social sciences / Raymond A. Barnett, Michael R. Ziegler, Karl E. Byleen. —9th ed.
p. cm.
Includes index.
ISBN 0-13-092054-1
1. Mathematics. 2. Social sciences—Mathematics. 3. Biomathematics. I. Ziegler, Michael R. II. Byleen, Karl. III. Title.

QA37.2.B364 2002 CIP
510—dc21 00-052843

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Art Studio: *Artworks:*
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Illustrators: *Mark Landis, Steve McKinley*

Prentice Hall

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Upper Saddle River, NJ 07458

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Printed in the United States of America
10 9 8 7 6 5 4 3 2

ISBN 0-13-092054-1

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Pearson Education Singapore, Pte. Ltd.
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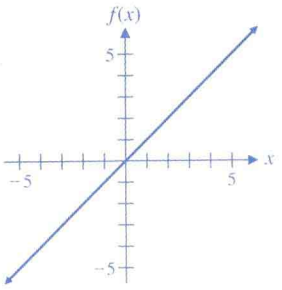
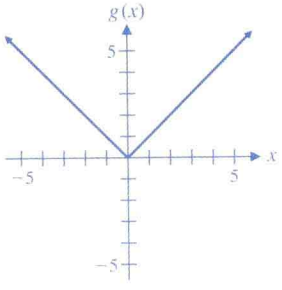
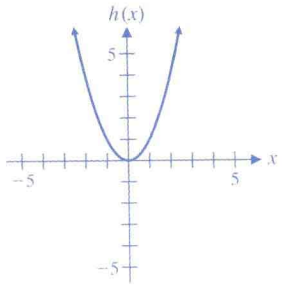


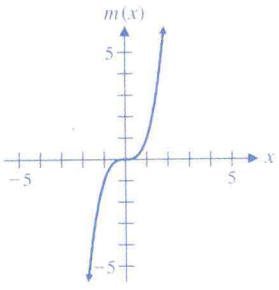
Identity function
$f(x) = x$



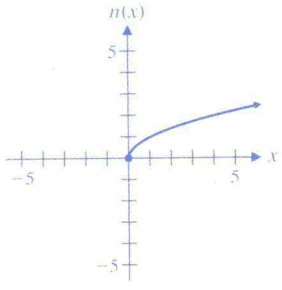
Absolute value function
$g(x) = |x|$



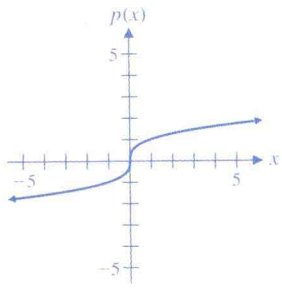
Square function
$h(x) = x^2$



Cube function
$m(x) = x^3$

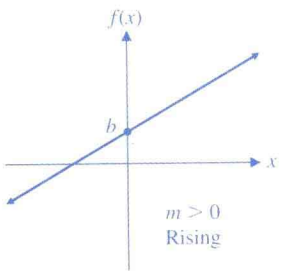


Square root function
$n(x) = \sqrt{x}$

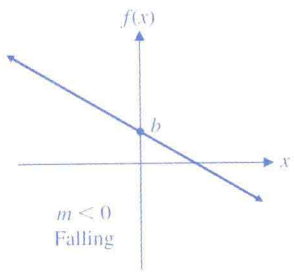


Cube root function
$p(x) = \sqrt[3]{x}$

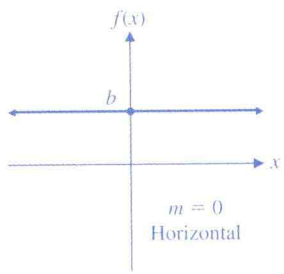
FIRST-DEGREE POLYNOMIAL FUNCTIONS



Linear function
$f(x) = mx + b$

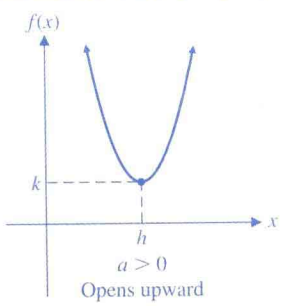


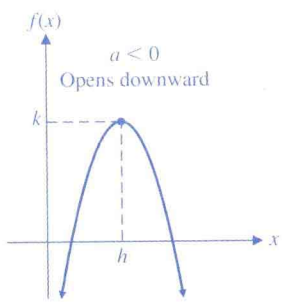
Linear function
$f(x) = mx + b$



Constant function
$f(x) = b$

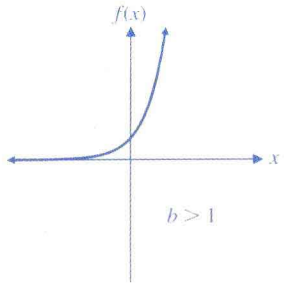
SECOND-DEGREE POLYNOMIAL FUNCTIONS



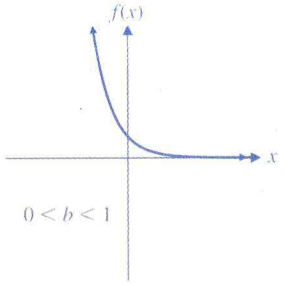


$f(x) = ax^2 + bx + c = a(x - h)^2 + k$

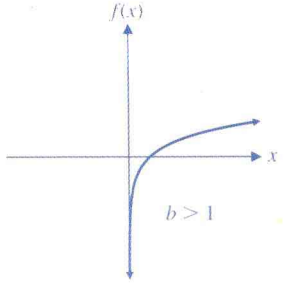
EXPONENTIAL AND LOGARITHMIC FUNCTIONS



Exponential function
$f(x) = b^x$

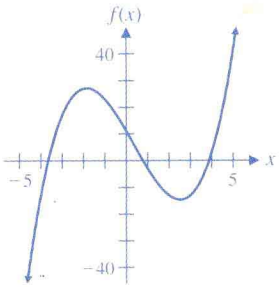


Exponential function
$f(x) = b^x$

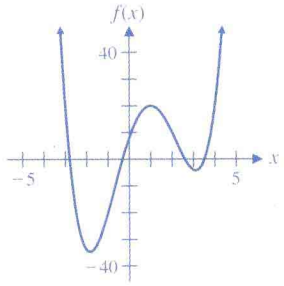


Logarithmic function
$f(x) = \log_b x$

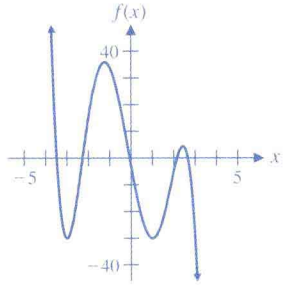
REPRESENTATIVE POLYNOMIAL FUNCTIONS (DEGREE > 2)



Third-degree polynomial
$f(x) = x^3 - x^2 - 14x + 11$

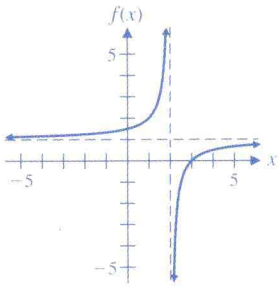


Fourth-degree polynomial
$f(x) = x^4 - 3x^3 - 9x^2 + 23x + 8$

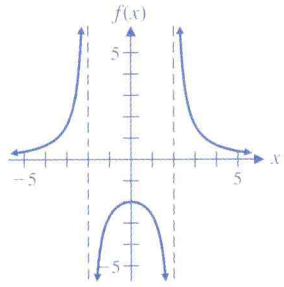


Fifth-degree polynomial
$f(x) = -x^5 - x^4 + 14x^3 + 6x^2 - 45x - 3$

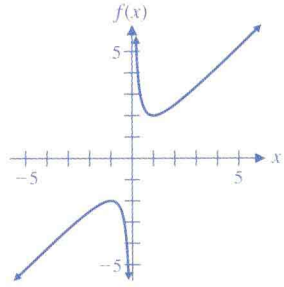
REPRESENTATIVE RATIONAL FUNCTIONS



$f(x) = \dfrac{x-3}{x-2}$

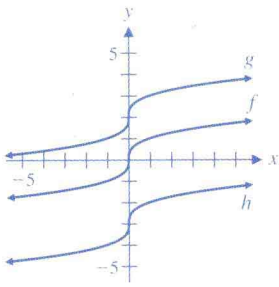


$f(x) = \dfrac{8}{x^2-4}$

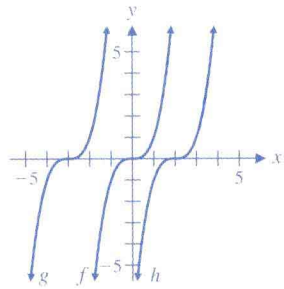


$f(x) = x + \dfrac{1}{x}$

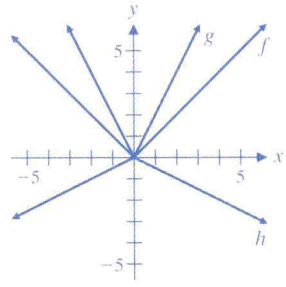
GRAPH TRANSFORMATIONS



Vertical translation
$g(x) = f(x) + 2$
$h(x) = f(x) - 3$



Horizontal translation
$g(x) = f(x + 3)$
$h(x) = f(x - 2)$



Expansion, contraction, and reflection
$g(x) = 2f(x)$
$h(x) = -0.5f(x)$

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Applications Index

Business & Economics

Absolute equality of income, 832
Absolute inequality of income, 832
Add-on interest loan, 171
Advertising, 108, 320, 355, 472, 568, 654, 692, 737, 752, 779, 878, 887
Agricultural exports and imports, 631
Air freight, 227
Amortization, 163, 165, 168, 169, 170, 171, 172, 173, 174
Amortization schedule, 163, 164, 169, 173
Annual interest rate, 103, 105
Annual nominal rate, 139, 140, 146
Annual percentage yield (APY), 145
Annuity, 151, 153, 156, 158, 159, 161, 168, 169, 170, 171, 172, 173, 174
Automation, 897
Automobile production, 67
Average cost, 93, 639, 664, 670, 671, 692, 813
Average price, 809, 863
Average production, 928
Average profit, 591
Average rate of change, 513
Average revenue, 591
Balance sheet, 153
Bonus incentives, 432
Break-even analysis, 13, 62, 67, 68, 72, 73, 190, 260, 595, 596, 601, 939, 990, 993
Break-even point, 62, 588
Brokerage commissions, 138, 150
Budgeting for least cost, 907
Budgeting for maximum production, 907
Business closings, 388
Business leases, 213, 260
Capital expansion, 294
Car rental, 473, 686
Certificate of deposit (CD), 145, 146, 150, 173
City planning, 933
Cobb–Douglas production function, 872, 928
Communications, 375
Competitive product, 888
Complementary product, 888
Compound interest, 72, 138, 140, 149, 150, 172, 173, 174, 554, 584, 600, 696, 872, 1002, 1003, 1019
Computer control systems, 428
Constant profit line, 282
Construction, 73, 320, 692
Construction costs, 670, 686, 687, 693
Consumer debt, 541
Consumer Price Index (CPI), 653, 991
Consumer survey, 422
Consumer testing, 403
Consumers' surplus, 844, 845, 848, 849, 856, 861, 863, 866
Continuous compound interest, 105, 123, 698, 701, 739, 772, 779, 795
Continuous income stream, 840, 842, 855, 863, 866
Cost(s), 13, 14, 46, 990
Cost analysis, 46, 226, 585, 591, 593, 600, 653, 795, 812, 813, 818, 819, 897
Cost function, 14, 51, 587, 751, 756, 768, 863, 878
Cost rate, 737
Cost–revenue–profit, 594, 595 734, 737, 870, 878
Decision analysis, 446, 450, 455
Delivery charges, 190
Demand analysis, 72
Demand equation, 740, 813, 887
Depreciation, 51, 102
Diet, 185, 249, 908
Distribution of wealth, 836
Doubling rate, 701, 702
Doubling time, 118, 120, 149, 699, 701, 702, 739, 820
Duration of telephone calls, 838
Economics, 939
Economy stimulation, 1018, 1019
Effective rate, 146
Elasticity of demand, 740
Electricity consumption, 554
Electricity rates, 34, 35, 72
Employee benefits, 367
Employee layoffs, 388
Employee rating, 440, 479
Employee screening, 440
Employee training, 89, 473, 500, 504, 600, 670, 795, 812, 819
Energy consumption, 52, 914
Equilibrium point, 47, 51, 72, 94, 121, 124, 186
Equilibrium price, 47, 186, 845
Equilibrium quantity, 47, 186, 845
Equipment rental, 621
Equity, 165, 166, 170, 174
Face value, 132, 150
Finance, 108, 356
Financial analysis, 554
Financial assets, 976
Fixed costs, 13, 46, 990
Future value, 103, 132, 137, 140, 149, 878
  of an annuity, 151, 152, 153, 158, 172, 173
  of a continuous income stream, 841, 855, 863, 866
Grain markets, 849, 868
Gross domestic product (GDP), 939
Gross receipts, 958, 959
Growth time, 144, 699, 701
Homeowners insurance, 473
Hospital costs, 34
Housing trends, 474
Incentive plans, 249
Income, 621
Income distribution, 832, 835, 836, 856, 863, 866, 867
Income tax, 213, 214
Index of income concentration, 832
Individual retirement account (IRA), 149, 156, 158, 159, 172, 174, 878
Inelastic demand, 741
Inflation, 653, 993
Input–output analysis, 250, 254, 257, 258, 261
Insurance, 417, 446, 450, 455, 465, 478, 483, 484
Interest, 103, 104, 132, 134, 135, 157, 172, 173, 174
Internal rate of return, 176
Internet growth, 110
Inventory
  average, 682, 813, 819
  control, 682, 687, 692
  value, 226
Investment(s), 120, 244, 261, 294, 320, 356, 357, 360, 939, 958, 993
Isoprofit line, 282
Keogh retirement plan, 158
Labor, 522, 897
Labor costs, 219, 222, 226, 261
Labor costs and learning, 757, 813
Labor force, 483
Labor relations, 432
Leontief input–output model, 250
Linear depreciation, 72
Linear regression, 74, 127, 908
Loans, 133, 162, 163, 168, 169, 170, 171, 172, 173, 174, 356, 500, 1017, 1019
Lorenz curve, 831
Maintenance costs, 812
Management selection, 374
Manufacturing, 278, 279, 293, 320, 321, 337, 355, 356, 360, 417, 686
Manufacturing costs, 687, 756
Marginal analysis, 562, 584, 639, 739
Marginal average cost, 590
Marginal average profit, 591
Marginal average revenue, 591
Marginal cost, 562, 564, 567, 583, 585, 670, 671
Marginal productivity
  of capital, 882
  of labor, 882
  of money, 903
Marginal profit, 585, 589, 805
Marginal revenue, 585, 588
Market analysis, 455
Market equilibrium, 186
Market research, 368, 375, 412, 417, 455, 504
Market share, 483, 484
Marketing, 500, 504, 769, 819, 863, 864, 942, 944
Markup, 72, 226
Material costs, 261, 897
Maximum profit, 677, 678, 685, 686, 692, 693, 709, 712, 723, 724, 739, 897, 917, 931
Maximum rate of change, 649
Maximum revenue, 60, 677, 685, 692, 713, 723, 739
Maximum volume, 686, 898, 907, 908
Maximum yield, 680
Membership selection, 403
Mineral production, 523
Minimizing cost, 897
Minimizing material, 897, 931
Minimum average cost, 94, 123, 601, 671, 692, 713, 740
Minimum wage, 375
Mining, 337
Money growth, 108, 123, 124
Mortgages, 163, 165, 166, 169, 170, 173, 174
Motor vehicle operation, 567
Motor vehicle production, 567, 917
Multiplier principle (economics), 928
Natural gas consumption, 600
Natural gas rates, 29, 620, 621, 691
Office rental costs, 149
Oil production, 769, 814, 835, 855
Operational costs, 687
Ordinary annuity, 151, 152
Package design, 872, 879, 894, 904
Packaging, 21, 22, 321, 686
Parking receipts, 248
Pensions, 501
Personnel selection, 388, 403, 432
Petroleum blending, 350, 356
Petroleum consumption, 52
Point of diminishing returns, 649, 741
Pollution cleanup costs, 670
Postal rates, 620
Present value, 103, 108, 132, 134, 137, 140, 142, 701
  of an annuity, 159, 161, 168
  of a continuous income stream, 848
Price analysis, 638, 691
Price–demand analysis, 20, 34, 46, 568, 576, 584, 587, 737, 765, 864
Price–demand function, 14, 51, 587, 768, 779, 813, 868
Price–supply analysis, 34, 576, 583, 819
Price–supply function, 768, 779, 813, 868
Pricing, 72
Producers price index (PPI), 653
Producers' surplus, 845, 848, 849, 856, 860, 863, 866
Product defects, 424, 437, 440
Product demand, 888
Product mix, 321, 369, 897
Product switching, 504
Product testing, 417
Production scheduling, 213, 249, 280, 293, 337, 348, 356, 363
Production strategy, 587
Productivity, 872, 878, 882, 887, 902, 907, 931
Profit analysis, 21, 523, 541, 593, 594, 638, 653, 670, 805, 814, 819, 855, 894, 931, 990
Profit function, 14, 589, 864, 882, 887

Profit rate, 737
Profit–loss analysis, 13, 68, 73
Promissory note, 108
Public debt, 976, 977
Purchasing, 209, 337
Quality control, 388, 408, 417, 432, 456
Rapid transit, 484
Real estate, 814
Real estate development, 490
Refund anticipation loan (RAL), 138, 173
Renewable energy, 756
Rental income, 686, 692
Replacement time, 93, 94, 670
Resale value, 724
Resource allocation, 190, 191, 248, 249, 260, 261, 275, 278, 279, 293, 320, 321, 338, 355, 357, 360
Resource depletion, 819
Retirement planning, 161
Revenue analysis, 13, 20, 67, 512, 523, 541, 594, 632, 638, 653, 670, 795, 796, 814, 990
Revenue–cost–profit, 594, 734, 737, 870, 878
Revenue function, 14, 588, 756, 769, 864, 866, 878, 887
Revenue rate, 737, 740
Rule of 72, 150
Sales analysis, 51, 52, 548, 553, 554, 573, 575, 576, 600, 756, 856, 887
Sales commissions, 217
Salvage value, 72, 724, 812
Scheduling, 321, 472
Scrap value, 51
Service contracts, 473
Shipping schedule, 360
Simple interest, 50, 132, 137, 138, 172, 173, 174, 696, 871
Sinking fund, 155, 158, 173
Sports lottery, 458
Sports salaries, 109
Spreadsheet, 153, 193, 218, 223, 235, 236, 243, 246, 255, 317, 333
State income tax, 35
Substitute product, 888
Supply and demand, 120, 186, 189, 190, 1000, 1001, 1002
  equilibrium point, 47, 121, 1000
  equilibrium price, 47, 845
  equilibrium quantity, 47, 845
Taxable income, 214
Telecommunications, 124
Telephone rates, 620
Tire mileage, 66
Total income, 840, 848
Traffic flow, 214, 215, 262
Transportation, 293, 294, 375, 455, 483
Transportation problem (linear programming), 330, 337, 360
Treasury bill (T-bill), 134, 137, 173, 174
True interest rate, 146
Truth in Lending Act, 171
Two-industry input–output model, 250, 254, 257, 258, 261
Unpaid loan balance, 165
Useful life, 806, 812, 813, 819, 835
Variable cost, 14, 46, 990
Warranty, 865, 866
Water consumption, 847
Yield to maturity, 175
Zero coupon bond, 180

Life Sciences

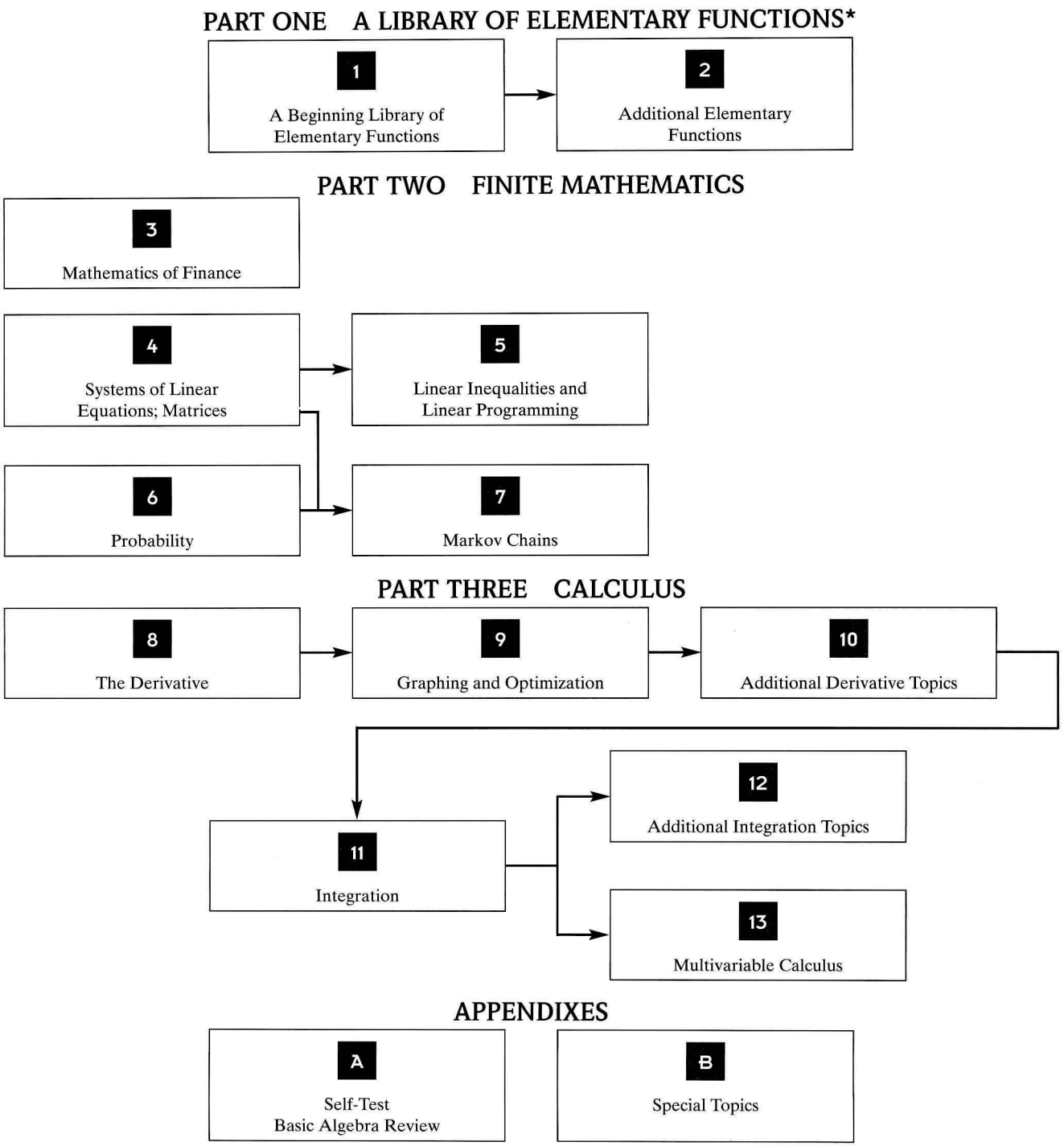
Agriculture, 121, 125, 289, 315, 515, 686, 908
AIDS epidemic, 109
Air pollution, 73, 554, 688, 819, 856, 864, 918, 929, 933, 977
Alveolar pressure, 542
Animal supply, 621
Bacteria control, 687, 693
Bacteria growth, 100, 584, 654, 724, 725
Beef production, 917
Bioclimatic rule, 918
Biology, 724, 769, 780, 814, 836, 918
Biophysics, 731
Bird flights, 687
Blood flow, 68, 872, 879, 888
Blood pressure, 713, 724, 780
Blood types, 945
Botany, 688
Cancer screening, 440
Carbon-14 dating, 101, 121, 702, 775, 780, 820
Cardiogram test, 456
Color-blindness, 433
Decibel, 121
Dental insurance, 474
Diet, 185, 249, 908
Drugs
  adverse reactions, 417
  dosage and concentration, 288, 639, 671, 687, 713, 740, 780
  rate of assimilation, 856, 866
  sensitivity, 576, 654
Ecology, 52, 568, 994, 1003
Epidemics, 780
Erosion, 1003
Exponential decay, 101, 773, 777
Exponential growth, 100, 773, 777
False negative result, 437
False positive result, 436
Family planning, 375
Food and Drug Administration, 433
Food processing, 356, 360
Gene mutations, 484
Genetics, 433, 450, 456, 484, 504
Global warming, 918
Growth constant, 773
Growth time, 144, 699, 701
Half-life, 702
Health care expenditures, 95, 523, 524
Health insurance, 473
Heredity, 228
Infant mortality, 524
Insecticides, 780
Laboratory management, 687
Leukemia, 124
Life expectancy, 110, 932
Light intensity, 109, 124
Marine biology, 109, 124, 879, 932
Medical research, 388, 403, 440
Medicare, 125
Medicine, 68, 124, 273, 288, 375, 388, 403, 417, 456, 501, 555, 568, 576, 601, 639, 671, 769, 796, 814, 815, 856, 866, 867, 888, 918
Muscle contraction, 22, 671, 731
Natural resource depletion, 836
Nuclear accident, 780
Nutrition, 52, 191, 214, 227, 279, 294, 322, 337, 338, 355, 356, 357, 360, 959
Photic zone, 109
Physiology, 35, 95, 542, 671
Poiseuille's law, 68, 872, 879, 888
Pollution, 73, 584, 601, 670, 688, 713, 737, 769, 819, 820, 856, 864, 929, 932, 977
Pollution control, 294
Population distribution (insects), 929
Pregnancy testing, 440
Pulse rate, 918
Radioactive decay, 702, 775
Resource depletion, 819
Respiration, 815
Shelf life, 847
Smoking, 505
Sound intensity, 121
Temperature, 814
Tuberculosis screening, 436, 440
Unlimited growth law, 777
Urban growth, 757
Water pollution, 584, 601, 670, 713, 737, 769, 864
Weight of fish, 84
Weight–height relationship, 757
Wildlife management, 993
Wound healing, 740, 757, 769, 796, 814, 820
Yield analysis, 680

Social Sciences

Anthropology, 994
Approach–avoidance, 191
Archaeology, 121, 775, 780, 820
Averaging tests, 228
Carbon-14 dating, 101, 121, 702, 775, 780, 820
Cephalic index, 879, 889, 994
City planning, 933
Clique, 945
College enrollment, 770
Crime, 977
Cryptography, 236, 237, 239, 240, 261
Decoding matrix, 237
Divorce, 96
Dominance relation, 228, 229, 262
Education, 249, 338, 357, 542, 919, 932
Educational testing, 913, 932
Encoding matrix, 236
Family planning, 375
Filibuster, 485
Gambler's ruin, 506
Grade-point average (GPA), 919
Group structures, 945
Intelligence quotient (IQ), 872, 879, 994
Learning, 36, 95, 568, 569, 576, 584, 601, 621, 655, 688, 713, 737, 740, 757, 769, 776, 780, 796, 820, 836, 856, 864
Learning curve, 109
Limited growth law, 777
Logistic growth law, 741, 777
Marriage, 96
Motivation, 53
Olympic games, 919
Opinion survey, 322
Perception, 780
Physical anthropology, 879, 889
Police science, 441
Politics, 22, 228, 375, 376, 388, 418, 441, 450, 485, 639, 688, 693, 725, 815, 856, 864, 867, 919
Population, 555, 601
Population composition, 815
Population density, 932, 977
Population growth, 110, 125, 654, 702, 773, 774, 820
Population shifts, 485
Psychology, 53, 73, 191, 279, 295, 433, 501, 671, 713, 740, 867, 879, 929, 994
Retention, 671
Rumor spread, 781
Safety research, 36, 420, 879, 889, 929, 1003
Sensory perception, 73
Skinner conditioning box, 279, 295
Small group analysis, 780
Sociology, 214, 295, 418, 505, 725, 932
University enrollment, 468, 494
Urban growth, 757
Voter preference, 456
Voting coalition, 944
Voting patterns, 433
Voting population, 688
Weber's law, 73, 713, 780
Women in the work force, 933
World population growth, 110, 121, 702

Dedicated to Phyllis Niklas, whose expertise, diligence, and patience helped make this series a success.

Chapter Dependencies



*Selected topics from Part One may be referred to as needed in Parts Two or Three or reviewed systematically before starting Part Two.

Preface

The ninth edition of *College Mathematics for Business, Economics, Life Sciences, and Social Sciences* is designed for a two-term (or condensed one term) course in finite mathematics and calculus for students who have had $1\frac{1}{2}$–2 years of high school algebra or the equivalent. The choice and independence of topics make the text readily adaptable to a variety of courses (see the Chapter Dependency Chart on page ix). It is one of five books in the authors' college mathematics series.

Improvements in this edition evolved out of the generous response from a large number of users of the last and previous editions as well as survey results from instructors, mathematics departments, course outlines, and college catalogs. Fundamental to a book's growth and effectiveness is classroom use and feedback. Now in its ninth edition, *College Mathematics for Business, Economics, Life Sciences, and Social Sciences* has had the benefit of having a substantial amount of both.

■ Emphasis and Style

The text is **written for student comprehension.** Great care has been taken to write a book that is mathematically correct and accessible to students. Emphasis is on computational skills, ideas, and problem solving rather than mathematical theory. Most derivations and proofs are omitted except where their inclusion adds significant insight into a particular concept. General concepts and results are usually presented only after particular cases have been discussed.

■ Examples and Matched Problems

Over 400 completely worked examples are used to introduce concepts and to demonstrate problem-solving techniques. Many examples have multiple parts, significantly increasing the total number of worked examples. Each example is followed by a similar **matched problem for the student to work** while reading the material. This actively involves the student in the learning process. The answers to these matched problems are included at the end of each section for easy reference.

■ Exploration and Discussion

Every section contains **Explore–Discuss** problems interspersed at appropriate places to encourage the student to think about a relationship or process before a result is stated, or to investigate additional consequences of a development in the text. **Verbalization** of mathematical concepts, results, and processes is encouraged in these Explore–Discuss problems, as well as in some matched problems, and in some problems in almost every exercise set. The Explore–Discuss

material also can be used as in-class or out-of-class **group activities.** In addition, at the end of every chapter, we have included two special **chapter group activities** that involve several of the concepts discussed in the chapter. Problems in the exercise sets that require verbalization are indicated by color problem numbers.

■ Exercise Sets

The book contains over 5,600 problems. Many problems have multiple parts, significantly increasing the total number of problems. Each exercise set is designed so that an average or below-average student will experience success and a very capable student will be challenged. Exercise sets are mostly divided into A (routine, easy mechanics), B (more difficult mechanics), and C (difficult mechanics and some theory) levels.

■ Applications

A major objective of this book is to give the student substantial experience in **modeling and solving real-world problems.** Enough applications are included to convince even the most skeptical student that mathematics is really useful (see the Applications Index inside the back cover). Worked examples involving applications are identified by or . **Almost every exercise set contains application problems,** usually divided into business and economics, life science, and social science groupings. An instructor with students from all three disciplines can let them choose applications from their own field of interest; if most students are from one of the three areas, then special emphasis can be placed there. Most of the applications are simplified versions of actual real-world problems taken from professional journals and books. No specialized experience is required to solve any of the applications.

■ Internet Connections

The Internet provides a wealth of material that can be related to this book, from sources for the data in application problems to interactive exercises that provide additional insight into various mathematical processes. Every section of the book contains Internet connections identified by (www). Links to the related web sites can be found at the **PH Companion Website** discussed later in this preface: `www.prenhall.com/barnett`

■ Technology

The generic term **graphing utility** is used to refer to any of the various graphing calculators or computer software packages that might be available to a student using this book. (See the description of the software accompanying this book later in this Preface.) Although **access to a graphing utility is not assumed,** it is likely that many students will want to make use of one of these devices. To assist these students, **optional graphing utility activities** are included in appropriate places in the book. These include brief discussions in the text, examples or portions of examples solved on a graphing utility, problems for the student to solve, and a **group activity that involves the use of technology** at the end of each

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chapter. In the group activity at the end of Chapter 1, and continuing through Chapter 2, **linear regression** on a graphing utility is used at appropriate points to illustrate **mathematical modeling with real data.** All the optional graphing utility material is clearly identified by either or and can be omitted without loss of continuity, if desired.

■ Graphs

All graphs are computer-generated to ensure mathematical accuracy. Graphing utility screens displayed in the text are actual output from a graphing calculator.

■ Additional Pedagogical Features

Annotation of examples and developments, in small color type, is found throughout the text to help students through critical stages (see Sections 1-1 and 4-2). **Think boxes** (dashed boxes) are used to enclose steps that are usually performed mentally (see Sections 1-1 and 4-1). **Boxes** are used to highlight important definitions, results, and step-by-step processes (see Sections 1-1 and 1-4). **Caution** statements appear throughout the text where student errors often occur (see Sections 4-3 and 4-5). **Functional use of color** improves the clarity of many illustrations, graphs, and developments, and guides students through certain critical steps (see Sections 1-1 and 4-2). **Boldface type** is used to introduce new terms and highlight important comments. **Chapter review** sections include a review of all important terms and symbols and a comprehensive review exercise. **Answers to most review exercises,** keyed to appropriate sections, are included in the back of the book. Answers to all other odd-numbered problems are also in the back of the book. Answers to application problems in linear programming include both the mathematical model and the numeric answer.

■ Content

The text begins with the development of a library of elementary functions in Chapters 1 and 2, including their properties and uses. We encourage students to investigate mathematical ideas and processes **graphically** and **numerically,** as well as **algebraically.** This development lays a firm foundation for studying mathematics both in this book and in future endeavors. Depending on the syllabus for the course and the background of the students, some or all of this material can be covered at the beginning of a course, or selected portions can be referred to as needed later in the course.

The material in Part Two (Finite Mathematics) can be thought of as four units: **mathematics of finance** (Chapter 3); linear algebra, including **matrices, linear systems, and linear programming** (Chapters 4 and 5); **probability** (Chapter 6); and applications of linear algebra and probability to **Markov chains** (Chapter 7). The first three units are independent of each other, while the last chapter is dependent on some of the earlier chapters (see the Chapter Dependency Chart preceding this Preface).

Chapter 3 presents a thorough treatment of simple and compound interest and present and future value of ordinary annuities. Appendix B contains a section on arithmetic and geometric sequences that can be covered in conjunction with this chapter, if desired.

Chapter 4 covers linear systems and matrices with an **emphasis on using row operations and Gauss–Jordan elimination** to solve systems and to find matrix inverses. This chapter also contains numerous applications of **mathematical modeling** utilizing systems and matrices. To assist students in formulating solutions, **all the answers in the back of the book to application problems** in Exercises 4-3, 4-5, and the chapter Review Exercise **contain both the mathematical model and its solution.** The row operations discussed in Sections 4-2 and 4-3 are required for the simplex method in Chapter 5. Matrix multiplication, matrix inverses, and systems of equations are required for Markov chains in Chapter 7.

Chapter 5 provides **broad and flexible coverage of linear programming.** The first two sections cover two-variable graphing techniques. Instructors who wish to emphasize techniques can cover the basic simplex method in Sections 5-3 and 5-4 and then discuss any or all of the following: the dual method (Section 5-5), the big M method (Section 5-6), or the two-phase simplex method (Group Activity 1). Those who want to emphasize modeling can discuss the formation of the mathematical model for any of the application examples in Sections 5-4, 5-5, and 5-6, and either omit the solution or use software to find the solution (see the description of the software that accompanies this text later in this Preface). To facilitate this approach, **all the answers in the back of the book to application problems** in Exercises 5-4, 5-5, 5-6, and the chapter Review Exercise **contain both the mathematical model and its solution.**

Chapter 6 covers **counting techniques and basic probability,** including Bayes' formula and random variables. Appendix A contains a review of basic set theory and notation to support the use of sets in probability.

Chapter 7 ties together concepts developed in earlier chapters and applies them to **Markov chains.** This provides an excellent unifying conclusion to the finite mathematics portion of the text.

The material in Part Three (Calculus) consists of **differential calculus** (Chapters 8–10), **integral calculus** (Chapters 11–12), and **multivariable calculus** (Chapter 13). In general, Chapters 8–11 must be covered in sequence; however, certain sections can be omitted or given brief treatments, as pointed out in the discussion that follows (see the Chapter Dependency Chart on page ix).

Chapter 8 introduces the **derivative,** covers the **limit properties** essential to understanding the definition of the derivative, develops the **rules of differentiation** (including the chain rule for power forms), and introduces **applications** of derivatives in business and economics. The interplay between graphical, numerical, and algebraic concepts is emphasized here and throughout the text.

Chapter 9 focuses on **graphing** and **optimization.** The first three sections cover continuity and first-derivative and second-derivative graph properties, while emphasizing **polynomial graphing. Rational function** graphing is covered in Section 9-4. In a course that does not include graphing rational functions, this section can be omitted or given a brief treatment. Optimization is covered in Section 9-5, including examples and problems involving end-point solutions.

The first three sections of Chapter 10 extend the derivative concepts discussed in Chapters 8 and 9 to **exponential and logarithmic functions** (including the general form of the chain rule). This material is required for all the remaining chapters. **Implicit differentiation** is introduced in Section 10-4 and applied to **related rate problems** in Section 10-5. These topics are not referred to elsewhere in the text and can be omitted.

Chapter 11 introduces **integration.** The first two sections cover **antidifferentiation** techniques essential to the remainder of the text. Section 11-3 discusses some applications involving **differential equations** that can be omitted. Sections 11-4 and 11-5 discuss the **definite integral** in terms of **Riemann sums,** including

approximations with various types of sums and some **simple error estimation.** As before, the interplay between the graphical, numeric, and algebraic properties is emphasized. These two sections also are required for the remaining chapters in the text.

Chapter 12 covers **additional integration topics** and is organized to provide maximum flexibility for the instructor. The first section extends the area concepts introduced in Chapter 11 to the area between two curves and related applications. Section 12-2 covers three more **applications** of integration, and Sections 12-3 and 12-4 deal with additional **techniques of integration.** Any or all of the topics in Chapter 12 can be omitted.

The first five sections of Chapter 13 deal with **differential multivariable calculus** and can be covered any time after Section 10-3 has been completed. Section 13-6 requires the **integration** concepts discusses in Chapter 11.

Appendix A contains a **self-test** and a **concise review of basic algebra** that also may be covered as part of the course or referred to as needed. As mentioned above, Appendix B contains additional topics that can be covered in conjunction with certain sections in the text, if desired.

■ Supplements for the Student

1. A **Student Solutions Manual** by Garret J. Etgen is available through your book store. The manual includes detailed solutions to all odd-numbered problems and all review exercises.
2. **Computer software and documentation** for IBM-compatible computers are packaged with the *Student Solutions Manual. Explorations in Finite Mathematics* and *Visual Calculus* by David Schneider each contain over twenty routines that provide additional insight into the topics discussed in the text. Although these software packages have much of the computing power of standard mathematical software packages, they are primarily teaching tools that focus on understanding mathematical concepts, rather than on computing. All the routines in these software packages are menu-driven and very easy to use. Included in *Explorations in Finite Mathematics* are routines for Gaussian elimination, matrix inversion, solution of linear programming problems by both the geometric method and the simplex method, Markov chains, probability and statistics, and mathematics of finance. The matrix routines use and display rational numbers, and matrices may be saved and printed. The *Visual Calculus* routines incorporate graphics whenever possible to illustrate topics such as secant lines; tangent lines; velocity; optimization; the relationship between the graphs of f, f', and f''; and the various approaches to approximating definite integrals. The software will run on DOS or Windows platforms.
3. The **PH Companion Website,** designed to complement and expand upon the text, offers a variety of teaching and learning tools, including links to related websites, practice work for students, and the ability for instructors to monitor and evaluate students' work on the website. For more information, contact your local Prentice Hall representative.
   `www.prenhall.com/barnett`
4. **CourseCompass/Blackboard/WebCT** offers Course compatible content including Excel Projects, Quizzes, Chapter Destinations, Lecture Notes, and Graphing Calculator Help. **CourseCompass** is the perfect course management solution that combines quality Pearson Education content with

state-of-the-art Blackboard technology! It is a dynamic, interactive online course management tool powered by Blackboard. This exciting product allows you to learn with market-leading Pearson Education content in an easy-to-use customizable format. **Blackboard 5^{SM}** is a comprehensive and flexible e-Learning software platform that delivers a course management system, customizable institution-wide portals, online communities, and an advanced architecture that allows for Web-based integration of multiple administrative systems. **WebCT** is one of the most popular Web course platforms in higher education today. It is the first destination site for the higher education marketplace to offer both teaching and learning resources and a community of peers across course and institutional boundaries.

■ Supplements for the Instructor

For a summary of all available supplementary materials and detailed information regarding examination copy requests and orders, see page xix.

1. **TestGen EQ Computerized Test Bank, a menu-driven random test system** for either Windows or Macintosh is available to instructors.
2. A **Test Item File,** prepared by Laurel Technical Services, provides a hard copy of the test items available in TestGen EQ.
3. An **Instructor's Solutions Manual** provides detailed solutions to the problems not solved in the Student Solutions Manual. This manual is available to instructors without charge.
4. A **Student Solutions Manual** by Garret J. Etgen (see Supplements for the Student) is available to instructors.
5. **Computer software and documentation** for *Explorations in Finite Mathematics* and *Visual Calculus* by David Schneider are available to instructors. The software and documentation are packaged with the *Student Solutions Manual* (see Supplements for the Student). In addition to providing students with the opportunity to use the computer as an effective tool in the learning process, instructors will find the software very useful for activities such as preparing examples for class, constructing test questions, and classroom demonstrations.
6. The **PH Companion Website,** designed to complement and expand upon the text, offers a variety of interactive teaching and learning tools, including links to related websites, practice work for students, and the ability for instructors to monitor and evaluate students' work on the website. For more information, contact your local Prentice Hall representative.
   `www.prenhall.com/barnett`
7. **CourseCompass/Blackboard/WebCT** offers Course compatible content including Excel Projects, Quizzes, Chapter Destinations, Lecture Notes, and Graphing Calculator Help. **CourseCompass** is the perfect course management solution that combines quality Pearson Education content with state-of-the-art Blackboard technology! It is a dynamic, interactive online course management tool powered by Blackboard. This exciting product allows you to teach with market-leading Pearson Education content in an easy-to-use customizable format. **Blackboard 5^{SM}** is a comprehensive and flexible e-Learning software platform that delivers a course management system, customizable institution-wide portals, online communities, and an advanced architecture that allows for Web-based inte-

gration of multiple administrative systems. **WebCT** is one of the most popular Web course platforms in higher education today. It is the first destination site for the higher education marketplace to offer both teaching and learning resources and a community of peers across course and institutional boundaries.

■ Error Check

Because of the careful checking and proofing by a number of mathematics instructors (acting independently), the authors and publisher believe this book to be substantially error-free. For any errors remaining, the authors would be grateful if they were sent to: Karl E. Byleen, 9322 W. Garden Court, Hales Corners, WI 53130; or, by e-mail, to: byleen@execpc.com

■ Acknowledgments

In addition to the authors, many others are involved in the successful publication of a book.

We wish to thank the following reviewers of the eighth edition:

Dale M. Rohm, University of Wisconsin–Stevens Point

A. J. Dickelman, University of Wisconsin–Stevens Point

Mary Ann Teel, University of North Texas

Jane D. Tanner, Onondaga Community College

We also wish to thank our colleagues who have provided input on previous editions:

Chris Boldt, Bob Bradshaw, Celeste Carter, Bruce Chaffee, Robert Chaney, Dianne Clark, Charles E. Cleaver, Barbara Cohen, Richard L. Conlon, Catherine Cron, Lou D'Alotto, Madhu Deshpande, John Dickerson, Kenneth A. Dodaro, Michael W. Ecker, Jerry R. Ehman, Lucina Gallagher, Joel Haack, Martha M. Harvey, Sue Henderson, Lloyd R. Hicks, Louis F. Hoelzle, Paul Hutchins, K. Wayne James, Robert H. Johnston, Robert Krystock, Inessa Levi, James T. Loats, Frank Lopez, Roy H. Luke, Wayne Miller, Mel Mitchell, Michael Montano, Ronald Persky, Shala Peterman, Kenneth A. Peters, Jr., Dix Petty, Tom Plavchak, Bob Prielipp, Stephen Rodi, Arthur Rosenthal, Sheldon Rothman, Elaine Russell, John Ryan, Daniel E. Scanlon, George R. Schriro, Arnold L. Schroeder, Hari Shanker, Larry Small, Joan Smith, Steven Terry, Delores A. Williams, Caroline Woods, Charles W. Zimmerman, and Pat Zrolka.

We also express our thanks to:

Hossein Hamedani, Carolyn Meitler, Stephen Merrill, Robert Mullins, and Caroline Woods for providing a careful and thorough check of all the mathematical calculations in the book, and to Priscilla Gathoni for checking the *Student Solutions Manual,* and the *Instructor's Solutions Manual* (a tedious but extremely important job).

Garret Etgen, Hossein Hamedani, Carolyn Meitler, and David Schneider for developing the supplemental manuals that are so important to the success of a text.

Jeanne Wallace for accurately and efficiently producing most of the manuals that supplement the text.

George Morris and his staff at Scientific Illustrators for their effective illustrations and accurate graphs.

All the people at Prentice Hall who contributed their efforts to the production of this book, especially Quincy McDonald, our acquisitions editor, and Lynn Savino Wendel, our production editor.

Producing this new edition with the help of all these extremely competent people has been a most satisfying experience.

R. A. Barnett
M. R. Ziegler
K. E. Byleen

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