Contents

Preface хi

To the Student xxii

Diagnostic Tests xxiv

A PREVIEW OF CALCULUS

Functions and Models 9



- Four Ways to Represent a Function 10 1.1
- Mathematical Models: A Catalog of Essential Functions 1.2 23
- New Functions from Old Functions 36 1.3
- 1.4 **Graphing Calculators and Computers** 44
- 1.5 **Exponential Functions**
- 1.6 Inverse Functions and Logarithms 58 Review 72

Principles of Problem Solving 75

Limits and Derivatives 81



- 2.1 The Tangent and Velocity Problems 82
- 2.2 The Limit of a Function
- 2.3 Calculating Limits Using the Limit Laws 99
- 2.4 The Precise Definition of a Limit 108
- 118 2.5 Continuity
- 2.6 Limits at Infinity; Horizontal Asymptotes 130
- 2.7 Derivatives and Rates of Change

Writing Project • Early Methods for Finding Tangents

2.8 The Derivative as a Function 154

> Review 165

Problems Plus 170

3 Differentiation Rules 173



3.1	Derivatives of Polynomials and Exponential Functions 174
	Applied Project • Building a Better Roller Coaster 184
3.2	The Product and Quotient Rules 184
3.3	Derivatives of Trigonometric Functions 191
3.4	The Chain Rule 198
	Applied Project • Where Should a Pilot Start Descent? 208
3.5	Implicit Differentiation 209
	Laboratory Project • Families of Implicit Curves 217
3.6	Derivatives of Logarithmic Functions 218
3.7	Rates of Change in the Natural and Social Sciences 224
3.8	Exponential Growth and Decay 237
3.9	Related Rates 244

250

274

3.10 Linear Approximations and Differentials

Laboratory Project - Taylor Polynomials 256

3.11 Hyperbolic Functions 257 Review 264

Problems Plus 268

4.1

4 Applications of Differentiation 273

Maximum and Minimum Values



	Applied Project = The Calculus of Rainbows 282
4.2	The Mean Value Theorem 284
4.3	How Derivatives Affect the Shape of a Graph 290
4.4	Indeterminate Forms and l'Hospital's Rule 301
	Writing Project • The Origins of l'Hospital's Rule 310
4.5	Summary of Curve Sketching 310
4.6	Graphing with Calculus and Calculators 318
4.7	Optimization Problems 325
	Applied Project = The Shape of a Can 337
4.8	Newton's Method 338
4.9	Antiderivatives 344

Problems Plus 355

Review

351

5 Integrals 359



- **5.1** Areas and Distances 360
- 5.2 The Definite Integral 371

 Discovery Project = Area Functions 3
- **5.3** The Fundamental Theorem of Calculus 386
- 5.4 Indefinite Integrals and the Net Change Theorem 397Writing Project = Newton, Leibniz, and the Invention of Calculus 406
- 5.5 The Substitution Rule 407 Review 415

Problems Plus 419

Applications of Integration 421



- 6.1 Areas Between Curves 422

 Applied Project The Gini Index 429
- **6.2** Volumes 430
- **6.3** Volumes by Cylindrical Shells 441
- **6.4** Work 446
- Average Value of a Function 451

 Applied Project = Calculus and Baseball 455

 Applied Project = Where to Sit at the Movies 450

Review 457

Problems Plus 459

7 Techniques of Integration 463



- **7.1** Integration by Parts 464
- **7.2** Trigonometric Integrals 471
- **7.3** Trigonometric Substitution 478
- **7.4** Integration of Rational Functions by Partial Fractions 484
- **7.5** Strategy for Integration 494
- 7.6 Integration Using Tables and Computer Algebra Systems 500Discovery Project = Patterns in Integrals 505

7.7	Approximate	Integration	506
	Approximate	micgianon	200

519 7.8 Improper Integrals Review 529

Problems Plus 533

Further Applications of Integration 537



8.1 Arc Length 538 Discovery Project - Arc Length Contest

8.2 Area of a Surface of Revolution 545 Discovery Project - Rotating on a Slant 551

8.3 Applications to Physics and Engineering 552 Discovery Project - Complementary Coffee Cups 562

8.4 Applications to Economics and Biology 563

8.5 Probability 568 575 Review

Problems Plus 577

Differential Equations 579



- 9.1 Modeling with Differential Equations 580
- 9.2 Direction Fields and Euler's Method 585
- Separable Equations 9.3 Applied Project - How Fast Does a Tank Drain? Applied Project • Which Is Faster, Going Up or Coming Down? 604
- 9.4 Models for Population Growth 605
- 9.5 Linear Equations 616
- 9.6 **Predator-Prey Systems** 622 Review 629

Problems Plus 633

Parametric Equations and Polar Coordinates 635



10.1	Curves Defined by Parametric Equations	636	
	Laboratory Project - Running Circles around C	Circles	644

- 10.2 Calculus with Parametric Curves 645 Laboratory Project - Bézier Curves 653
- 10.3 **Polar Coordinates** 654 Laboratory Project - Families of Polar Curves 664
- Areas and Lengths in Polar Coordinates 10.4 665
- 10.5 Conic Sections 670
- 10.6 Conic Sections in Polar Coordinates 678 Review 685

Problems Plus 688

Infinite Sequences and Series 689



- 690 11.1 Sequences Laboratory Project - Logistic Sequences 703
- 703 11.2 Series
- The Integral Test and Estimates of Sums 714 11.3
- 11.4 The Comparison Tests 722
- 727 11.5 Alternating Series
- 11.6 Absolute Convergence and the Ratio and Root Tests 732
- Strategy for Testing Series 739 11.7
- 11.8 **Power Series** 741
- Representations of Functions as Power Series 11.9 746
- 11.10 Taylor and Maclaurin Series Laboratory Project - An Elusive Limit 767 Writing Project - How Newton Discovered the Binomial Series
- 11.11 **Applications of Taylor Polynomials** Applied Project - Radiation from the Stars 777 778 Review

Problems Plus 781