

Calculus

GLOBAL EDITION

Second Edition

WILLIAM BRIGGS

University of Colorado, Denver

LYLE COCHRAN

Whitworth University

BERNARD GILLETT

University of Colorado, Boulder

with the assistance of

ERIC SCHULZ

Walla Walla Community College

PEARSON

Boston Columbus Indianapolis New York San Francisco Upper Saddle River
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

Contents

Preface 12

Credits 19

1 Functions 23

- 1.1 Review of Functions 23
- 1.2 Representing Functions 34
- 1.3 Trigonometric Functions 48
- Review Exercises 56*

2 Limits 59

- 2.1 The Idea of Limits 59
- 2.2 Definitions of Limits 66
- 2.3 Techniques for Computing Limits 74
- 2.4 Infinite Limits 83
- 2.5 Limits at Infinity 92
- 2.6 Continuity 101
- 2.7 Precise Definitions of Limits 113
- Review Exercises 124*

3 Derivatives 127

- 3.1 Introducing the Derivative 127
- 3.2 Working with Derivatives 137
- 3.3 Rules of Differentiation 145
- 3.4 The Product and Quotient Rules 152
- 3.5 Derivatives of Trigonometric Functions 161
- 3.6 Derivatives as Rates of Change 169
- 3.7 The Chain Rule 183

3.8 Implicit Differentiation 193

3.9 Related Rates 201

Review Exercises 209

4 Applications of the Derivative 213

4.1 Maxima and Minima 213

4.2 What Derivatives Tell Us 222

4.3 Graphing Functions 237

4.4 Optimization Problems 246

4.5 Linear Approximation and Differentials 256

4.6 Mean Value Theorem 266

4.7 L'Hôpital's Rule 273

4.8 Newton's Method 281

4.9 Antiderivatives 289

Review Exercises 299

5 Integration 302

5.1 Approximating Areas under Curves 302

5.2 Definite Integrals 317

5.3 Fundamental Theorem of Calculus 331

5.4 Working with Integrals 346

5.5 Substitution Rule 353

Review Exercises 363

6 Applications of Integration 367

6.1 Velocity and Net Change 367

6.2 Regions Between Curves 381

6.3 Volume by Slicing 389

6.4 Volume by Shells 403

6.5 Length of Curves 414

6.6 Surface Area 419

6.7 Physical Applications 427

Review Exercises 439

7 Logarithmic and Exponential Functions 443

7.1 Inverse Functions 443

7.2 The Natural Logarithmic and Exponential Functions 453

7.3 Logarithmic and Exponential Functions with Other Bases 467

7.4 Exponential Models 477

- 7.5 Inverse Trigonometric Functions 487
- 7.6 L'Hôpital's Rule and Growth Rates of Functions 501
- 7.7 Hyperbolic Functions 508
- Review Exercises* 525

8 Integration Techniques 529

- 8.1 Basic Approaches 529
- 8.2 Integration by Parts 534
- 8.3 Trigonometric Integrals 541
- 8.4 Trigonometric Substitutions 549
- 8.5 Partial Fractions 559
- 8.6 Other Integration Strategies 569
- 8.7 Numerical Integration 575
- 8.8 Improper Integrals 588
- 8.9 Introduction to Differential Equations 599
- Review Exercises* 611

9 Sequences and Infinite Series 614

- 9.1 An Overview 614
- 9.2 Sequences 625
- 9.3 Infinite Series 637
- 9.4 The Divergence and Integral Tests 645
- 9.5 The Ratio, Root, and Comparison Tests 659
- 9.6 Alternating Series 667
- Review Exercises* 676

10 Power Series 679

- 10.1 Approximating Functions with Polynomials 679
- 10.2 Properties of Power Series 693
- 10.3 Taylor Series 702
- 10.4 Working with Taylor Series 714
- Review Exercises* 723

11 Parametric and Polar Curves 725

- 11.1 Parametric Equations 725
- 11.2 Polar Coordinates 737
- 11.3 Calculus in Polar Coordinates 750
- 11.4 Conic Sections 759
- Review Exercises* 772

| | | |
|-----------|--|-------------|
| 12 | Vectors and Vector-Valued Functions | 775 |
| | 12.1 Vectors in the Plane | 775 |
| | 12.2 Vectors in Three Dimensions | 788 |
| | 12.3 Dot Products | 799 |
| | 12.4 Cross Products | 810 |
| | 12.5 Lines and Curves in Space | 817 |
| | 12.6 Calculus of Vector-Valued Functions | 826 |
| | 12.7 Motion in Space | 835 |
| | 12.8 Length of Curves | 848 |
| | 12.9 Curvature and Normal Vectors | 859 |
| | <i>Review Exercises</i> | 872 |
| 13 | Functions of Several Variables | 876 |
| | 13.1 Planes and Surfaces | 876 |
| | 13.2 Graphs and Level Curves | 891 |
| | 13.3 Limits and Continuity | 903 |
| | 13.4 Partial Derivatives | 912 |
| | 13.5 The Chain Rule | 925 |
| | 13.6 Directional Derivatives and the Gradient | 934 |
| | 13.7 Tangent Planes and Linear Approximation | 946 |
| | 13.8 Maximum/Minimum Problems | 957 |
| | 13.9 Lagrange Multipliers | 969 |
| | <i>Review Exercises</i> | 977 |
| 14 | Multiple Integration | 981 |
| | 14.1 Double Integrals over Rectangular Regions | 981 |
| | 14.2 Double Integrals over General Regions | 991 |
| | 14.3 Double Integrals in Polar Coordinates | 1002 |
| | 14.4 Triple Integrals | 1012 |
| | 14.5 Triple Integrals in Cylindrical and Spherical Coordinates | 1025 |
| | 14.6 Integrals for Mass Calculations | 1041 |
| | 14.7 Change of Variables in Multiple Integrals | 1052 |
| | <i>Review Exercises</i> | 1064 |
| 15 | Vector Calculus | 1068 |
| | 15.1 Vector Fields | 1068 |
| | 15.2 Line Integrals | 1078 |
| | 15.3 Conservative Vector Fields | 1096 |
| | 15.4 Green's Theorem | 1105 |

15.5 Divergence and Curl 1118

15.6 Surface Integrals 1129

15.7 Stokes' Theorem 1144

15.8 Divergence Theorem 1153

Review Exercises 1165

Appendix A Algebra Review 1169

Appendix B Proofs of Selected Theorems 1177

Answers 1187

Index 1281

Table of Integrals

Sample pages