ESSENTIALS OF PRECALCULUS MATHEMATICS

Second Edition

Dennis T. Christy

Essentials of Precalculus Mathematics

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Dennis T. Christy
Nassau Community College

1817

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To Margaret Ellen, who made my project her project.

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Algebra

Exponents:

1. $x^m \cdot x^n = x^{m+n}$
2. $(x^m)^n = x^{mn}$
3. $\dfrac{x^m}{x^n} = x^{m-n}$
4. $x^0 = 1$
5. $x^{-n} = \left(\dfrac{1}{x}\right)^n = \dfrac{1}{x^n}$
6. $x^{1/n} = \sqrt[n]{x}$

Radicals:

1. $(\sqrt[n]{x})^n = x$
2. $\sqrt[n]{x} \cdot \sqrt[n]{y} = \sqrt[n]{xy}$
3. $\dfrac{\sqrt[n]{x}}{\sqrt[n]{y}} = \sqrt[n]{\dfrac{x}{y}}$
4. $\sqrt[n]{x^m} = (\sqrt[n]{x})^m = x^{m/n}$
5. $\sqrt[n]{x^n} = x$, if n is odd
6. $\sqrt[n]{x^n} = |x|$, if n is even

Logarithms:

1. $\log_b xy = \log_b x + \log_b y$
2. $\log_b \dfrac{x}{y} = \log_b x - \log_b y$
3. $\log_b (x)^k = k \log_b x$
4. $\log_b b^x = x$
5. $b^{\log_b x} = x$
6. $\log_b x = \dfrac{\log_a x}{\log_a b}$

Quadratic Formula

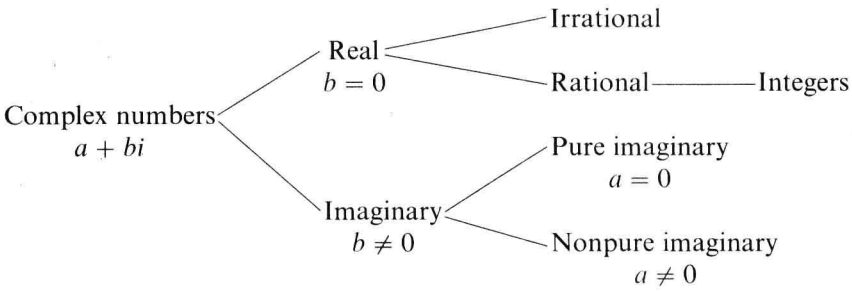
If $ax^2 + bx + c = 0$ and $a \neq 0$, then

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Factoring Models

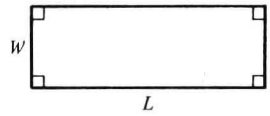
1. Common factor: $ax + ay = a(x + y)$
2. Difference of squares: $x^2 - y^2 = (x + y)(x - y)$
3. Trinomial (leading coefficient 1): $x^2 + (a + b)x + ab = (x + a)(x + b)$
4. Perfect square trinomial: $x^2 + 2xy + y^2 = (x + y)^2$
5. General trinomial: $(ac)x^2 + (ad + bc)x + bd = (ax + b)(cx + d)$
6. Sum of cubes: $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$
7. Difference of cubes: $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$

Number Relations

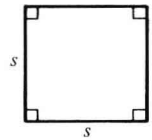


Geometric Formulas

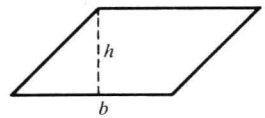
1. Rectangle
   Area: $A = LW$
   Perimeter: $P = 2L + 2W$



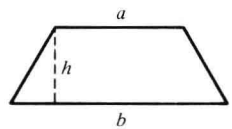
2. Square
   Area: $A = s^2$
   Perimeter: $P = 4s$



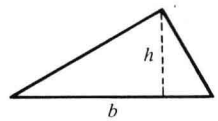
3. Parallelogram
   Area: $A = bh$



4. Trapezoid
   Area: $A = \frac{1}{2}h(a + b)$



5. Triangle
   Area: $A = \frac{1}{2}bh$



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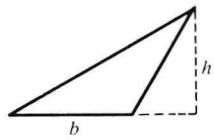
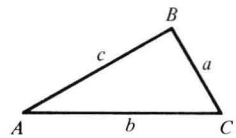
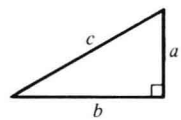


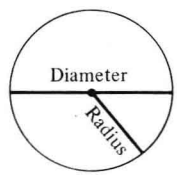
   Area: $A = \sqrt{s(s-a)(s-b)(s-c)}$,
   where $s = \frac{1}{2}(a + b + c)$
   Angle sum: $A + B + C = 180°$



6. Right Triangle
   Pythagorean theorem: $a^2 + b^2 = c^2$



7. Circle
   Area: $A = \pi r^2$
   Circumference: $c = \pi d = 2\pi r$



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Essentials of Precalculus Mathematics

Preface to the Second Edition

"This book is intended for students who need a concrete approach to mathematics. Set theory is omitted and notation is kept to a minimum. The text stresses problem solving and includes many applications that indicate the need for analyzing concepts with mathematical tools."

With these words I began the Preface to the First Edition of *Essentials of Precalculus Mathematics*. This book was well received by a wide variety of users who had many nice things to say about the text. Thus, the first thing that should be said about this second edition is that the philosophy and approach of the first edition remain intact.

My experience continues to be that college students who need precalculus mathematics learn best by "doing." Examples and exercises are crucial since it is usually in these areas that the students' main interaction with the material takes place. This text contains brief, precisely formulated paragraphs, followed by many detailed examples. Each section has many exercises for both in-class practice and homework. The problem sets are carefully graded and contain an unusual number of routine manipulative problems. (There is nothing more frustrating than being stuck on the beginning exercises!) So that each student may be challenged fairly, difficult problems have been included. There is also a wide variety of questions and discussions that show the student the usefulness of mathematics. Many users of the first edition felt that the quality and abundance of the exercises and examples were an outstanding feature of this text.

All the essential precalculus topics are covered, and it should be easy to design a one- or two-semester course that satisfies individual needs. As indicated in the table of contents, the text is divided into two parts. Part One covers the fundamentals of algebra along with an introduction to functions and trigonometry. Students enrolled in engineering or technology programs require this early discussion of trigonometry. This organization also provides the opportunity to carry the trigonometric expressions along simultaneously with the work in algebra so that students can see that algebraic and trigonometric expressions are handled in basically the same way.

Part Two uses an "elementary functions" approach, with the function concept playing the unifying role in the study of polynomial, rational, exponential, logarithmic, and circular functions. Analytical geometry is integrated throughout the text, and Chapter 11 discusses the conic sections. Sequences and series have been added to this part as supplementary topics.

The presentation assumes that the student has a background that includes algebra and geometry. However, a thorough review of all the necessary ideas is given so that students whose basic skills need improvement should do well with this book. After this course the student can proceed directly to the study of calculus.

Although the main thrust of the first edition is unchanged, the second edition contains many significant improvements. Briefly, the major ones are as follows:

1. New sections are included on absolute value equations and inequalities (1.9), graphing techniques (2.5), solving inequalities by factoring (4.6), theorems about polynomial zeros (8.5), sequences (12.1), series (12.2), and infinite geometric series (12.3).
2. Many harder algebra problems were added in Chapters 4–6 with special emphasis on simplifying the types of expressions encountered in a calculus course.
3. The chapter tests in the first edition are replaced by chapter exercises that contain a much wider variety of ideas. These exercise sets consist of about 50 or 60 problems that not only review the basic ideas but also contain (a) questions about the basic material asked in a different way from in the chapter; (b) questions on topics slightly out of the mainstream (for example, the golden rectangle); and (c) questions that extend ideas covered in the chapter.
4. Sections 8.1–8.5 from the first edition were moved to Chapter 7 to balance out a chapter that was too short (Chapter 7) with a chapter that was too long (Chapter 8). The material from Chapter 2 is now reviewed in just one section (7.1), and this section was rewritten in a style more suitable to review material.
5. Important formulas and tables from algebra, geometry, and trigonometry are now listed on the endpapers.
6. A second color is used to highlight important ideas.

I wish to thank the many users and reviewers of the book who have suggested improvements. At this point, it is hard to separate my original ideas from the many valuable observations they made, and I am indebted to all of them. I am especially grateful to Tom Carnevale of Essex County College, Sharmon Hilfinger and the staff of Harper & Row, and Abraham Weinstein and Gene Zirkel of Nassau Community College, who each contributed in different but major ways. My wife, Margaret, once again helped in the many special ways that are needed to keep a writer going. So, to my family, my colleagues at Nassau Community College, the staff at Harper & Row, and the many users and reviewers, thank you.

Dennis T. Christy

Trigonometry

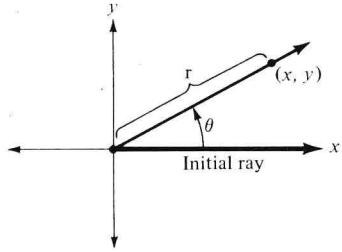
Definition of the Trigonometric Functions If θ is an angle in standard position and if (x, y) is any point on the terminal ray of θ [except $(0, 0)$], then:

$$\sin\theta = \frac{y}{r} \quad \leftarrow \text{reciprocals} \rightarrow \quad \csc\theta = \frac{r}{y}$$

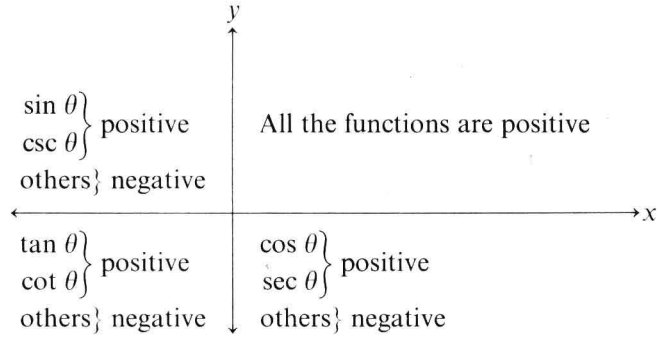
$$\cos\theta = \frac{x}{r} \quad \leftarrow \text{reciprocals} \rightarrow \quad \sec\theta = \frac{r}{x}$$

$$\tan\theta = \frac{y}{x} \quad \leftarrow \text{reciprocals} \rightarrow \quad \cot\theta = \frac{x}{y}$$

Note: $r = \sqrt{x^2 + y^2}$



Signs of the Trigonometric Ratios

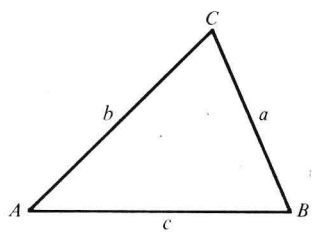


Exact Values of Special Angles

θ		$\sin\theta$	$\csc\theta$	$\cos\theta$	$\sec\theta$	$\tan\theta$	$\cot\theta$
degrees	radians						
0°	0	0	not defined	1	1	0	not defined
30°	$\frac{\pi}{6}$	$\frac{1}{2}$	2	$\frac{\sqrt{3}}{2}$	$\frac{2}{\sqrt{3}}$	$\frac{1}{\sqrt{3}}$	$\sqrt{3}$
45°	$\frac{\pi}{4}$	$\frac{1}{\sqrt{2}}$	$\sqrt{2}$	$\frac{1}{\sqrt{2}}$	$\sqrt{2}$	1	1
60°	$\frac{\pi}{3}$	$\frac{\sqrt{3}}{2}$	$\frac{2}{\sqrt{3}}$	$\frac{1}{2}$	2	$\sqrt{3}$	$\frac{1}{\sqrt{3}}$
90°	$\frac{\pi}{2}$	1	1	0	not defined	not defined	0
180°	π	0	not defined	−1	−1	0	not defined
270°	$\frac{3\pi}{2}$	−1	−1	0	not defined	not defined	0

Law of Sines

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$



Law of Cosines

$$a^2 = b^2 + c^2 - 2bc\cos A$$
$$b^2 = a^2 + c^2 - 2ac\cos B$$
$$c^2 = a^2 + b^2 - 2ab\cos C$$

Trigonometric Identities

1. $\sin x \csc x = 1$ or $\sin x = \dfrac{1}{\csc x}$ or $\csc x = \dfrac{1}{\sin x}$

2. (

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

13.

14.

15.

16.

17.

18.

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ESSENTIALS OF PRECALCULUS
MATHEMATICS
second edition
Dennis T. Christy
578 pp. $18.50t

A problem-solving approach is used in this text to stress computational skills rather than applications. Trigonometry is introduced early and then carried along with algebra. Complete algebra review included although exposure to algebra and trigonometry is assumed. Infinite geometrics series and theorems about polynomial zeroes provide challenging topics. Exercises follow each section. End-of-chapter problems consolidate the concepts presented in the chapter. Answers to odd-numbered problems given.

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19. $\sin \dfrac{x}{2} = \pm\sqrt{\dfrac{1 - \cos x}{2}}$

20. $\cos \dfrac{x}{2} = \pm\sqrt{\dfrac{1 + \cos x}{2}}$

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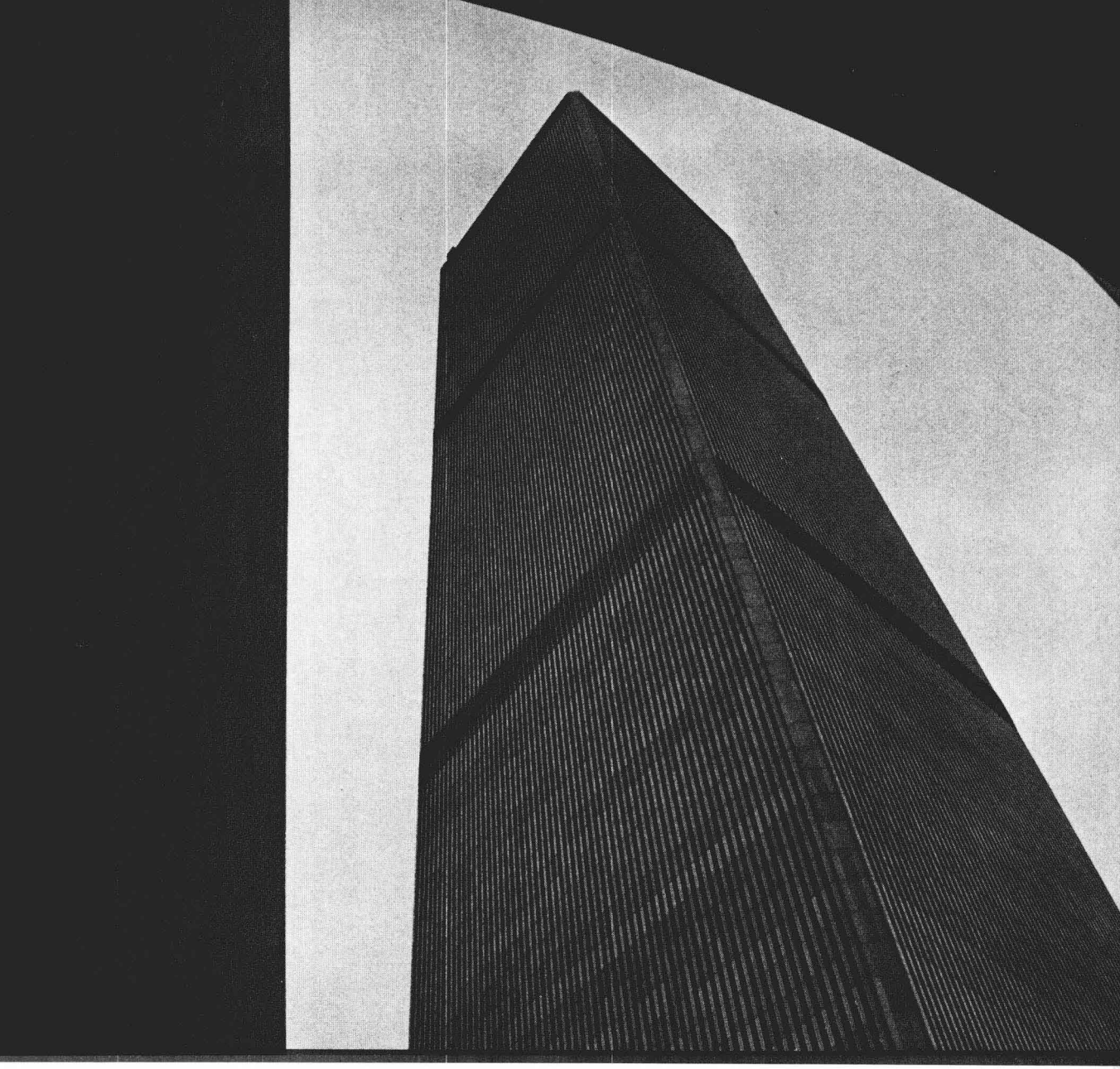

PART 1

Algebra with an Introduction to Trigonometry

1

Basic Concepts and Operations

1·1 Number Systems

Mathematics is a basic tool in analyzing concepts in every field of human endeavor. In fact, the primary reason you have studied this subject for at least a decade is that mathematics is the most powerful instrument available in the search to understand the world and to control it. Mathematics is essential for full comprehension of technological and scientific advances, economic policies and business

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