# Chapter **3**

# **Rational Functions**

### **Curriculum Expectations**

#### **Polynomial and Rational Functions**

#### **Connecting Graphs and Equations of Rational Functions**

**C2.1** determine, through investigation with and without technology, key features (i.e., vertical and horizontal asymptotes, domain and range, intercepts, positive/ negative intervals, increasing/decreasing intervals) of the graphs of rational functions that are the reciprocals of linear and quadratic functions, and make connections between the algebraic and graphical representations of these rational functions [e.g., make connections between  $f(x) = \frac{1}{x^2 - 4}$  and its graph by using graphing technology and by reasoning that there are vertical asymptotes at x = 2 and x = -2 and a horizontal asymptote at y = 0 and that the function maintains the same sign as  $f(x) = x^2 - 4$ ]

#### Technology Notes

The technology used in this chapter includes graphing calculators, specifically the TI-83 Plus/TI-84 Plus series, a computer algebra system (CAS), specifically the TI-89/ 89T series, and *The Geometer's Sketchpad*<sup>®</sup>.

C2.2 determine, through investigation with and without technology, key features (i.e., vertical and horizontal asymptotes, domain and range, intercepts, positive/negative intervals, increasing/decreasing intervals) of the

graphs of rational functions that have linear expressions in the numerator and denominator [e.g.,  $f(x) = \frac{2x}{x-3}$ ,

 $h(x) = \frac{x-2}{3x+4}$ ], and make connections between the algebraic and graphical representations of these rational functions

**C2.3** sketch the graph of a simple rational function using its key features, given the algebraic representation of the function

#### Solving Polynomial and Rational Equations

C3.5 determine, through investigation using technology (e.g., graphing calculator, computer algebra systems), the connection between the real roots of a rational equation and the *x*-intercepts of the graph of the corresponding rational function, and describe this connection [e.g., the real root of the equation  $\frac{x-2}{x-3} = 0$  is 2, which is the *x*-intercept of the function  $f(x) = \frac{x-2}{x-3}$ ; the equation  $\frac{1}{x-3} = 0$  has no real roots, and the function  $f(x) = \frac{1}{x-3}$  does not intersect the *x*-axis]

C3.6 solve simple rational equations in one variable algebraically, and verify solutions using technology (e.g., using computer algebra systems to determine the roots; using graphing technology to determine the x-intercepts of the graph of the corresponding rational function)

C3.7 solve problems involving applications of polynomial and simple rational functions and equations [e.g., problems involving the factor theorem or remainder theorem, such as determining the values of k for which the function  $f(x) = x^3 + 6x^2 + kx - 4$  gives the same remainder when divided by x - 1 and x + 2]

#### Solving Inequalities

C4.1 explain, for polynomial and simple rational functions, the difference between the solution to an equation in one variable and the solution to an inequality in one variable, and demonstrate that given solutions satisfy an inequality (e.g., demonstrate numerically and graphically that the solution to  $\frac{1}{x+1} < 5$  is x < -1 or  $x > -\frac{4}{5}$ )

#### **Characteristics of Functions**

#### Understanding Rates of Change

**D1.3** sketch a graph that represents a relationship involving rate of change, as described in words, and verify with technology (e.g., motion sensor) when possible

**D1.5** recognize examples of instantaneous rates of change arising from real-world situations, and make connections between instantaneous rates of change and average rates of change (e.g., an average rate of change can be used to approximate an instantaneous rate of change)

**D1.6** determine, through investigation using various representations of relationships (e.g., tables of values, graphs, equations), approximate instantaneous rates of change arising from real-world applications (e.g., in the natural, physical, and social sciences) by using average rates of change and reducing the interval over which the average rate of change is determined

**D1.7** make connections, through investigation, between the slope of a secant on the graph of a function (e.g., quadratic, exponential, sinusoidal) and the average rate of change of the function over an interval, and between the slope of the tangent to a point on the graph of a function and the instantaneous rate of change of the function at that point

**D1.8** determine, through investigation using a variety of tools and strategies (e.g., using a table of values to calculate slopes of secants or graphing secants and measuring their slopes with technology), the approximate slope of the tangent to a given point on the graph of a function (e.g., quadratic, exponential, sinusoidal) by using the slopes of secants through the given point (e.g., investigating the slopes of secants that approach the tangent at that point more and more closely), and make connections to average and instantaneous rates of change

**D1.9** solve problems involving average and instantaneous rates of change, including problems arising from real-world applications, by using numerical and graphical methods (e.g., by using graphing technology to graph a tangent and measure its slope)

#### **Combining Functions**

**D2.2** recognize real-world applications of combinations of functions (e.g., the motion of a damped pendulum can be represented by a function that is the product of a trigonometric function and an exponential function; the frequencies of tones associated with the numbers on a telephone involve the addition of two trigonometric functions), and solve related problems graphically

#### Using Function Models to Solve Problems

D3.1 compare, through investigation using a variety of tools and strategies (e.g., graphing with technology; comparing algebraic representations; comparing finite differences in tables of values) the characteristics (e.g., key features of the graphs, forms of the equations) of various functions (i.e., polynomial, rational, trigonometric, exponential, logarithmic)

D3.2 solve graphically and numerically equations and inequalities whose solutions are not accessible by standard algebraic techniques

## Chapter 3 Planning Chart

Section Suggested Timing	Student Text Page(s)	Teacher's Resource Blackline Masters	Assessment	Tools
Chapter 3 Opener • 10 min	145			
Prerequisite Skills <ul> <li>30 min</li> </ul>	146–147	<ul> <li>G–3 Four Quadrant Grids</li> <li>G–5 Number Lines</li> <li>BLM 3–1 Prerequisite Skills</li> </ul>		• grid paper
<ul><li>3.1 Reciprocal of a</li><li>Linear Function</li><li>75 min</li></ul>	148–155	<ul> <li>G-1 Grid Paper</li> <li>T-2 The Geometer's Sketchpad® 4</li> <li>BLM 3-2 Section 3.1 Practice</li> </ul>		<ul> <li>grid paper</li> <li>graphing calculator</li> <li>OR</li> <li>computer</li> <li><i>The Geometer's Sketchpad</i>®</li> </ul>
Extension: Asymptotes and the TI-83 Plus or TI-84 Plus Graphing Calculator • 20–30 min	156			• graphing calculator
<ul> <li>3.2 Reciprocal of a</li> <li>Quadratic Function</li> <li>150 min</li> </ul>	157–167	<ul> <li>G-1 Grid Paper</li> <li>T-2 The Geometer's Sketchpad® 4</li> <li>BLM 3-3 Section 3.2 Practice</li> </ul>		<ul> <li>grid paper</li> <li>graphing calculator</li> <li>OR</li> <li>computer</li> <li><i>The Geometer's Sketchpad</i>®</li> </ul>
3.3 Rational Functions of the Form $f(x) = \frac{ax + b}{cx + d}$ • 75 min	168–176	<ul> <li>G-1 Grid Paper</li> <li>T-2 The Geometer's Sketchpad® 4</li> <li>BLM 3-4 Section 3.3 Practice</li> </ul>		<ul> <li>grid paper</li> <li>graphing calculator</li> <li>OR</li> <li>computer</li> <li>The Geometer's Sketchpad®</li> </ul>
3.4 Solving Rational Equations and Inequalities • 75–150 min	177–185	<ul> <li>G-1 Grid Paper</li> <li>G-5 Number Lines</li> <li>T-2 The Computer Algebra System (CAS) on the TI-89 Calculator</li> <li>BLM 3-5 Section 3.4 Practice</li> </ul>	• BLM 3–6 Section 3.4 Achievement Check Rubric	<ul> <li>grid paper</li> <li>graphing calculator</li> <li>computer algebra system</li> </ul>
3.5 Making Connections With Rational Functions and Equations • 75–150 min	186–191	<ul> <li>G–1 Grid Paper</li> <li>BLM 3–7 Section 3.5 Practice</li> </ul>		<ul><li> grid paper</li><li> graphing calculator</li></ul>
Chapter 3 Review • 75 min	192–193	<ul> <li>G–1 Grid Paper</li> <li>G–5 Number Lines</li> <li>BLM 3–8 Chapter 3 Review</li> </ul>		<ul><li> grid paper</li><li> graphing calculator</li></ul>
Chapter 3 Problem Wrap-Up • 40–60 min	193	• G–1 Grid Paper	• BLM 3–9 Chapter 3 Problem Wrap-Up Rubric	<ul><li> grid paper</li><li> graphing calculator</li></ul>
Chapter 3 Practice Test <ul> <li>75 min</li> </ul>	194–195	<ul> <li>G–1 Grid Paper</li> <li>G–5 Number Lines</li> </ul>	• BLM 3–10 Chapter 3 Test	• grid paper
Chapters 1 to 3 Review • 60–75 min	196–197	<ul> <li>G–1 Grid Paper</li> <li>G–5 Number Lines</li> </ul>		<ul><li> grid paper</li><li> graphing calculator</li></ul>
Chapter 3 Task: ZENN and Now • 60–75 min	198	BLM 3–12 BLM Answers	BLM 3–11 Task: ZENN     and Now Rubric	

## Chapter 3 Blackline Masters Checklist

Prerequisite Skills         G-3         Four Quadrant Grids         Student Support           G-5         Number Lines         Student Support           BLM 3-1         Prerequisite Skills         Practice           3.1 Reciprocal of a Linear Function         G-1         Grid Paper         Student Support           T-2         The Geometer's Stetchpad® 4         Technology           BLM 3-2         Section 3.1 Practice         Practice           Student Support           Student Support           Student Support           Student Support           Student Support           Student Support           Technology           BLM 3-3         Section 3.2 Practice         Practice           Student Support           T-2         The Geometer's Stetchpad® 4         Technology           BLM 3-3         Section 3.2 Practice         Practice           Student Support           T-2         The Geometer's Stetchpad® 4         Technology           BLM 3-4         Section 3.2 Practice         Practice           Student Support           T-2         The Geometer's Stetchpad® 4         Technology		BLM	Title	Purpose			
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T-2     The Geometer's Sketchpad® 4     Technology       BLM 3-4     Section 3.3 Practice     Practice       3.4 Solving Rational Equations and Inequalities        G-1     Grid Paper     Student Support       G-5     Number Lines     Student Support       T-4     The Computer Algebra System (CAS) on the TI-89 Calculator     Technology       BLM 3-5     Section 3.4 Practice     Practice       BLM 3-6     Section 3.4 Achievement Check Rubric     Assessment       3.5 Making Connections With Rational Functions and Equations      Practice       G-1     Grid Paper     Student Support       BLM 3-7     Section 3.5 Practice     Practice       Chapter 3 Review      Practice       G-1     Grid Paper     Student Support       BLM 3-8     Chapter 3 Review     Practice       Chapter 3 Review     Practice     Practice       Chapter 3 Problem Wrap-Up      Assessment       G-1     Grid Paper     Student Support       BLM 3-9     Chapter 3 Problem Wrap-Up     Assessment       Chapter 3 Problem Wrap-Up     Assessment     Assessment       Chapter 3 Problem Wrap-Up Rubric     Assessment     Assessment       Chapter 3 Practice Test     Student Support     Student Support       G-5 <td></td> <td>G-1</td> <td>Grid Paper</td> <td>Student Support</td>		G-1	Grid Paper	Student Support			
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		BLM 3-12	BLM Answers	Answers			

# Prerequisite Skills

#### Student Text Pages

146 to 147

Suggested Timing 30 min

#### Tools

• grid paper

#### **Related Resources**

• G–3 Four Quadrant Grids

- G–5 Number Lines
- BLM 3–1 Prerequisite Skills

#### Assessment

You may wish to use BLM 3–1 Prerequisite Skills as a diagnostic assessment. Refer students to the Skills Appendix for examples and further practice of topics.

#### **Chapter Problem**

• The Chapter Problem is introduced on page 147. Have students discuss their understanding of the topic. The Chapter Problem is revisited in Sections 3.2 (question 13), 3.3 (question 10), and 3.4 (question 15). These questions are designed to help students move toward the Chapter 3 Problem Wrap-Up on page 193. Alternatively, you may wish to assign the Chapter Problem questions and Chapter Problem Wrap-Up when students have completed the chapter, as part of a summative assessment.