

# INTERMEDIATE ALGEBRA

TWELFTH EDITION



BITTINGER / BEECHER / JOHNSON

# Your Guide to Success in Math

Complete **Step 0** as soon as you begin your math course.

## STEP 0: PLAN YOUR SEMESTER

- Register for the online part of the course (if there is one) as soon as possible.
- Fill in your Course and Contact information on this pull-out card.
- Write important dates from your syllabus on the Semester Organizer on this pull-out card.

Follow **Steps 1–4** during your course. Your instructor will tell you which resources to use—and when—in the textbook or eText, *MyMathGuide* workbook, videos, and MyMathLab. Use these resources for extra help and practice.

## STEP 1: LEARN THE SKILLS AND CONCEPTS

- Read the **textbook** or **eText**, listen to your instructor’s lecture, and/or watch the **videos**. You can work in *MyMathGuide* as you do this. As you are learning:
  - Take notes, write down your questions, and save all your work (including homework solutions, quizzes, and tests) to review throughout the course.
  - Work the *Skill to Review* exercises at the beginning of each section.
  - Stop and do the *Margin* and *Guided Solution Exercises* as directed.
  - Watch the videos. Answer the *Interactive Your Turn* questions in the videos and in *MyMathGuide*.

## STEP 2: CHECK YOUR UNDERSTANDING

- Answer the *Reading Checks* in the Section Exercise sets or in MyMathLab.
- Explore the concepts using the *Active Learning Figures* in MyMathLab.

## STEP 3: DO YOUR HOMEWORK

- Plan to spend 2 hours studying and doing homework for every hour of class.
- Complete your assigned homework from the textbook and/or in MyMathLab.
  - When doing homework from the textbook, use the answer section to check your work.
  - When doing homework in MyMathLab, use the Learning Aids, such as Help Me Solve This and View an Example, as needed, working toward being able to complete exercises without the aids.

## STEP 4: REVIEW AND TEST YOUR UNDERSTANDING

- Work the exercises in the *Mid-Chapter Review*.
- Make your own chapter study sheet by doing the *Chapter Summary and Review*.
- Take the *Chapter Test* as a practice exam. To watch an instructor solve each problem, go to the Chapter Test Prep Videos in MyMathLab or on YouTube (search “BittingerInterm” and click on “Channels”).

Use the *Studying for Success* tips in the text and the MyMathLab **Study Skills modules** (with videos, tips, and activities) to help you develop effective time-management, note-taking, test-prep, and other skills.





# At a Glance: Intermediate Algebra

## Linear Functions and Slope

$$Ax + By = C: 2x - 3y = 6;$$

$$y = mx + b: y = \frac{2}{3}x - 2;$$

$$f(x) = mx + b: f(x) = \frac{2}{3}x - 2$$

$$\text{Slope } m = \frac{2}{3}$$

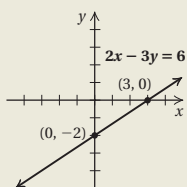
$$y\text{-intercept } (0, b) = (0, -2)$$

Slope of line through  $(-6, 2)$  and  $(4, -9)$ :

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-9 - 2}{4 - (-6)} = \frac{-11}{10} = -\frac{11}{10}$$

The slope of a horizontal line is 0.

The slope of a vertical line is not defined.



## Parallel Lines and Perpendicular Lines

Two lines are parallel if they have the same slope and different  $y$ -intercepts;

$$y = 2x - 3 \text{ and } y = 2x + 4 \text{ are parallel.}$$

Two nonvertical lines are perpendicular if the product of their slopes is  $-1$ :  $m_1 \cdot m_2 = -1$ ;

$$y = \frac{1}{2}x + 3 \text{ and } y = -2x - 7 \text{ are perpendicular.}$$

## Polynomials

**Multiplying:**

$$(y - 4)(3y + 5) = 3y^2 - 7y - 20$$

$$(q - 5)(q + 5) = q^2 - 25$$

$$(2a - 3)^2 = 4a^2 - 12a + 9$$

**Factoring:**

$$2x^2 - 5x - 12 = (2x + 3)(x - 4)$$

$$25x^2 - 4 = (5x - 2)(5x + 2)$$

$$9x^2 + 6x + 1 = (3x + 1)^2$$

$$x^3 + 64 = (x + 4)(x^2 - 4x + 16)$$

$$x^3 - 1000 = (x - 10)(x^2 + 10x + 100)$$

## Subtracting Rational Expressions

$$\begin{aligned} \frac{14}{x^2 - 9} - \frac{6}{x + 3} &= \frac{14}{(x + 3)(x - 3)} - \frac{6}{x + 3} \cdot \frac{x - 3}{x - 3} \\ &= \frac{14 - 6(x - 3)}{(x + 3)(x - 3)} = \frac{14 - 6x + 18}{(x + 3)(x - 3)} \\ &= \frac{32 - 6x}{(x + 3)(x - 3)} \end{aligned}$$

## Set-Builder Notation and Interval Notation

$$\{x \mid x \text{ is a real number}\} = (-\infty, \infty)$$

$$\{x \mid x < 3\} = (-\infty, 3)$$

$$\{x \mid -3 \leq x < 3\} = [-3, 3)$$

$$\{x \mid x \geq 3\} = [3, \infty)$$

## Solving Inequalities

**Using the Addition Principle and the Multiplication Principle**

$$-5x + 2 \leq -78$$

$$-5x \leq -80$$

$$x \geq 16$$

The solution set is  $\{x \mid x \geq 16\}$ , or  $[16, \infty)$ .

**Containing Absolute Value**

$$|x - 2| \leq 5$$

$$-5 \leq x - 2 \leq 5$$

$$-3 \leq x \leq 7$$

The solution set is  $\{x \mid -3 \leq x \leq 7\}$ , or  $[-3, 7]$ .

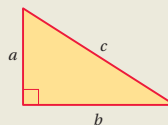
$$|x - 2| > 5$$

$$x - 2 < -5 \text{ or } x - 2 > 5$$

$$x < -3 \text{ or } x > 7$$

The solution set is  $\{x \mid x < -3 \text{ or } x > 7\}$ , or  $(-\infty, -3) \cup (7, \infty)$ .

## Pythagorean Theorem



$$a^2 + b^2 = c^2$$

## Radical Expressions

$$\begin{aligned} \sqrt{12x^3y^2} \cdot \sqrt{8xy} &= \sqrt{96x^4y^3} \\ &= \sqrt{16 \cdot 6 \cdot x^4 \cdot y^2 \cdot y} = 4x^2y\sqrt{6y} \end{aligned}$$

$$\frac{\sqrt{x^3}}{\sqrt{27}} = \frac{\sqrt{x^3}}{\sqrt{27}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3x^3}}{\sqrt{81}} = \frac{x\sqrt{3x}}{9}$$

$$\begin{aligned} \frac{1 - \sqrt{5}}{4 + \sqrt{5}} &= \frac{1 - \sqrt{5}}{4 + \sqrt{5}} \cdot \frac{4 - \sqrt{5}}{4 - \sqrt{5}} \\ &= \frac{4 - 5\sqrt{5} + 5}{16 - 5} = \frac{9 - 5\sqrt{5}}{11} \end{aligned}$$

$$\begin{aligned} \sqrt{45} + \sqrt{80} &= \sqrt{9 \cdot 5} + \sqrt{16 \cdot 5} \\ &= 3\sqrt{5} + 4\sqrt{5} = 7\sqrt{5} \end{aligned}$$

## Solving Equations

### Using the Principle of Zero Products

$$\begin{aligned}x^2 + 3x &= 54 \\x^2 + 3x - 54 &= 0 \\(x + 9)(x - 6) &= 0 \\x + 9 = 0 \quad \text{or} \quad x - 6 = 0 \\x = -9 \quad \text{or} \quad x = 6\end{aligned}$$

The solutions are  $-9$  and  $6$ .

### Using the Quadratic Formula

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

$$\begin{aligned}x^2 - 6x + 2 = 0; \quad a = 1, b = -6, c = 2 \\x = \frac{-(-6) \pm \sqrt{(-6)^2 - 4 \cdot 1 \cdot 2}}{2 \cdot 1} = \frac{6 \pm \sqrt{28}}{2} \\= \frac{6 \pm 2\sqrt{7}}{2} = 3 \pm \sqrt{7}\end{aligned}$$

The solutions are  $3 + \sqrt{7}$  and  $3 - \sqrt{7}$ , or  $3 \pm \sqrt{7}$ .

### Containing Absolute Value

$$\begin{aligned}|x - 2| &= 5 \\x - 2 = -5 \quad \text{or} \quad x - 2 = 5 \\x = -3 \quad \text{or} \quad x = 7\end{aligned}$$

The solutions are  $-3$  and  $7$ .

### Multiplying by the LCM

$$\begin{aligned}\frac{5}{4x} + \frac{1}{x} &= 2 \\4x \cdot \left(\frac{5}{4x} + \frac{1}{x}\right) &= 4x \cdot 2 \\5 + 4 &= 8x \\9 &= 8x \\\frac{9}{8} &= x\end{aligned}$$

The solution is  $\frac{9}{8}$ .

### Using the Principle of Square Roots

$$\begin{aligned}x^2 + 6x + 9 &= 16 \\(x + 3)^2 &= 16 \\x + 3 = 4 \quad \text{or} \quad x + 3 = -4 \\x = 1 \quad \text{or} \quad x = -7\end{aligned}$$

The solutions are  $1$  and  $-7$ .

### Using the Principle of Powers

$$\begin{aligned}\sqrt{x-1} - 3 &= 9 \\\sqrt{x-1} &= 12 \\(\sqrt{x-1})^2 &= 12^2 \\x - 1 &= 144 \\x &= 145\end{aligned}$$

The solution is  $145$ .

## Solving Systems of Equations Using the Elimination Method

$$\begin{array}{r}x - 3y = -7 \longrightarrow -2x + 6y = 14 \\2x + 5y = -3 \longrightarrow \underline{2x + 5y = -3} \\11y = 11 \\y = 1\end{array}$$

Substitute  $1$  for  $y$  in either equation and solve for  $x$ :

$$\begin{aligned}2x + 5 \cdot 1 &= -3 \\2x &= -8 \\x &= -4.\end{aligned}$$

The solution is  $(-4, 1)$ .

## Variation

|                  |                                    |                    |
|------------------|------------------------------------|--------------------|
| <b>Direct:</b>   | <b>Inverse:</b>                    | <b>Joint:</b>      |
| $y = kx; y = 6x$ | $y = \frac{k}{x}; y = \frac{2}{x}$ | $y = kxz; y = 9xz$ |

## Complex Numbers

$$\begin{aligned}i &= \sqrt{-1}; \quad i^2 = -1 \\(2 - 3i) + (6 + 2i) &= 8 - i \\\sqrt{-4} \cdot \sqrt{-15} &= 2i \cdot \sqrt{15}i = 2\sqrt{15}i^2 = -2\sqrt{15} \\-3 + 4i &= \frac{-3 + 4i}{1 - 6i} \cdot \frac{1 + 6i}{1 + 6i} = \frac{-27 - 14i}{1 - 36i^2} = \frac{-27 - 14i}{37} = -\frac{27}{37} - \frac{14}{37}i\end{aligned}$$

## Quadratic Functions

$$\begin{aligned}f(x) &= ax^2 + bx + c \\f(x) &= x^2 - x - 6 \\&= (x + 2)(x - 3)\end{aligned}$$

Function values:

$$\begin{aligned}f(0) &= -6, f(1) = -6, \\f(-2) &= 0, f(3) = 0, \\f(-1) &= -4, f(2) = -4\end{aligned}$$

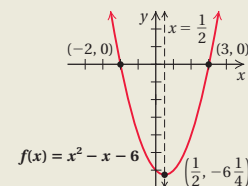
$x$ -intercepts:  $(-2, 0)$  and  $(3, 0)$

$$\text{Vertex: } \left(-\frac{b}{2a}, f\left(-\frac{b}{2a}\right)\right) = \left(\frac{1}{2}, -6\frac{1}{4}\right)$$

$$\text{Axis of symmetry: } x = \frac{1}{2}$$

Domain:  $(-\infty, \infty)$

$$\text{Range: } \left[-6\frac{1}{4}, \infty\right)$$



## Properties of Logarithms

$$\text{Product Rule: } \log_a(M \cdot N) = \log_a M + \log_a N$$

$$\text{Power Rule: } \log_a M^k = k \cdot \log_a M$$

$$\text{Quotient Rule: } \log_a \frac{M}{N} = \log_a M - \log_a N$$

# INTERMEDIATE ALGEBRA

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**MARVIN L. BITTINGER**

*Indiana University Purdue University Indianapolis*

**JUDITH A. BEECHER**

**BARBARA L. JOHNSON**

*Indiana University Purdue University Indianapolis*

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# Preface

## The Bittinger Program

Math hasn't changed, but students—and the way they learn it—have.

*Intermediate Algebra*, Twelfth Edition, continues the Bittinger tradition of objective-based, guided learning, while integrating timely updates to the proven pedagogy. In this edition, there is a greater emphasis on guided learning and helping students get the most out of all of the course resources available with the Bittinger program, including new opportunities for mobile learning.

The program has expanded to include these comprehensive new teaching and learning resources: **MyMathGuide workbook**, **To-the-Point Objective Videos**, and enhanced, media-rich **MyMathLab** courses. Feedback from instructors and students motivated these and several other significant improvements: a new design to support guided learning, new figures and photos to help students visualize both concepts and applications, and many new and updated real-data applications to bring the math to life.

With so many resources available in so many formats, the trusted guidance of the Bittinger team on *what to do* and *when* will help today's math students stay on task. Students are encouraged to use **Your Guide to Success in Math**, a four-step learning path and checklist available on the handy reference card in the front of this text and in MyMathLab. The guide will help students identify the resources in the textbook, supplements, and MyMathLab that support *their* learning style, as they develop and retain the skills and conceptual understanding they need to succeed in this and future courses.

In this preface, a look at the key new *and* hallmark resources and features of the *Intermediate Algebra* program—including the textbook/eText, video program, *MyMathGuide* workbook, and MyMathLab—is organized around **Your Guide to Success in Math**. This will help instructors direct students to the tools and resources that will help them most in a traditional lecture, hybrid, lab-based, or online environment.

## NEW AND HALLMARK FEATURES IN RELATION TO Your Guide to Success in Math

### STEP 1 Learn the Skills and Concepts

Students have several options for learning, reviewing, and practicing the math concepts and skills.

#### Textbook/eText

- Skill to Review.** At the beginning of nearly every text section, *Skill to Review* offers a just-in-time review of a previously presented skill that relates to the new material in the section. Section and objective references are included for the student's convenience, and two practice exercises are provided for review and reinforcement.
- Margin Exercises.** For each objective, problems labeled “Do Exercise . . .” give students frequent opportunities to solve exercises while they learn.

- New! Guided Solutions.** Nearly every section has *Guided Solution* margin exercises with fill-in blanks at key steps in the problem-solving process.
- Enhanced! MyMathLab.** MyMathLab now includes *Active Learning Figures* for directed exploration of concepts; more problem types, including *Reading Checks* and *Guided Solutions*; and new, objective-based videos. (See pp. xiv–xviii for a detailed description of the features of MyMathLab.)
  - New! Skills Checks.** In the Learning Path for Ready-to-Go MyMathLab, each chapter begins with a brief assessment of students' mastery of the prerequisite skills needed to learn the new material in the chapter. Based on the results of this pretest, a personalized homework set is designed to help each student prepare for the chapter.
- New! To-the-Point Objective Videos.** This is a comprehensive new program of objective-based, interactive videos that are incorporated into the Learning Path in MyMathLab and can be used hand-in-hand with the *MyMathGuide* workbook.
  - New! Interactive Your Turn Exercises.** For each objective in the videos, students solve exercises and receive instant feedback on their work.
- New! MyMathGuide: Notes, Practice, and Video Path.** This is an objective-based workbook (available printed and in MyMathLab) for guided, hands-on learning. It offers vocabulary, skill, and concept review—along with problem-solving practice—with space to show work and write notes. Incorporated in the Learning Path in MyMathLab, it can be used together with the To-the-Point Objective Video program, instructor lectures, and the textbook.

## STEP 2 Check Your Understanding

Throughout the program, students have frequent opportunities to check their work and confirm that they understand each skill and concept before moving on to the next topic.

- New! Reading Checks.** At the beginning of each set of section exercises in the text, students demonstrate their grasp of the skills and concepts.
- New! Active Learning Figures.** In MyMathLab, Active Learning Figures guide students in exploring math concepts and reinforcing their understanding.
- Translating/Visualizing for Success.** In the text and in MyMathLab, these activities offer students extra practice with the important first step of the process for solving applied problems.

## STEP 3 Do Your Homework

*Intermediate Algebra*, Twelfth Edition, has a wealth of proven and updated exercises. Prebuilt assignments are available for instructors in MyMathLab, and they are pre-assigned and incorporated into the Learning Path in the Ready-to-Go course.

- Skill Maintenance.** In each section, these exercises offer a thorough review of the math in the preceding text.
- Synthesis Exercises.** To help build critical-thinking skills, these section exercises require students to use what they know and combine learning objectives from the current section with those from previous sections.

## STEP 4 Review and Test Your Understanding

Students have a variety of resources to check their skills and understanding along the way and to help them prepare for tests.

- Mid-Chapter Review.** Midway through each chapter, students work a set of exercises (*Concept Reinforcement*, *Guided Solutions*, *Mixed Review*, and *Understanding Through Discussion and Writing*) to confirm that they have grasped the skills and concepts covered in the first half before moving on to new material.
- Summary and Review.** This resource provides an in-text opportunity for active learning and review for each chapter. *Vocabulary Reinforcement*, *Concept Reinforcement*, objective-based *Study Guide* (examples paired with similar exercises), *Review Exercises* (including *Synthesis* problems), and *Understanding Through Discussion and Writing* are included in these comprehensive chapter reviews.
- Chapter Test.** Chapter Tests offer students the opportunity for comprehensive review and reinforcement prior to taking their instructor’s exam. **Chapter Test-Prep Videos** (in MyMathLab and on YouTube) show step-by-step solutions to the Chapter Tests.
- Cumulative Review.** Following every chapter beginning with Chapter 2, a Cumulative Review revisits skills and concepts from all preceding chapters to help students retain previously learned material.

## Study Skills

Developing solid time-management, note-taking, test-taking, and other study skills is key to student success in math courses (as well as professionally and personally). Instructors can direct students to related study skills resources as needed.

- New! Student Study Reference.** This pull-out card at the front of the text is perforated, three-hole-punched, and binder-ready for convenient reference. It includes **Your Guide to Success in Math** course checklist, **Student Organizer**, and **At a Glance**, a list of key information and examples for quick reference as students work exercises and review for tests.
- New! Studying for Success.** Checklists of study skills—designed to ensure that students develop the skills they need to succeed in math, school, and life—are integrated throughout the text at the beginning of selected sections.
- New! Study Skills Modules.** In MyMathLab, interactive modules address common areas of weakness, including time-management, test-taking, and note-taking skills. Additional modules support career-readiness.

## Learning Math in Context

- New! Applications.** Throughout the text in examples and exercises, real-data applications encourage students to see and interpret the mathematics that appears every day in the world around them. Applications that use real data are drawn from business and economics, life and physical sciences, medicine, technology, and areas of general interest such as sports and daily life. New applications include “Rice Production” (pp. 95–96), “Physical Therapists” (p. 117), “Super Bowl Commercials” (p. 289), “Catering a Business Luncheon” (p. 454), “Beach Volleyball” (p. 593), and “Alternative Fueling Stations” (p. 676). For a complete list of applications, please refer to the Index of Applications (p. vii).



# BREAKTHROUGH

To improving results

## MyMathLab

### Ties the Complete Learning Program Together

#### MyMathLab® Online Course (access code required)

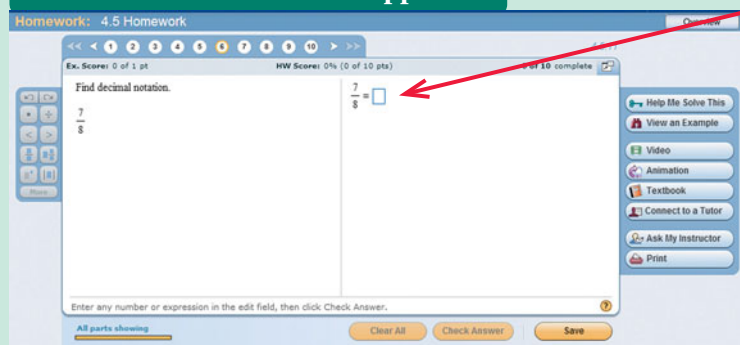
MyMathLab from Pearson is the world's leading online resource in mathematics, integrating interactive homework, assessment, and media in a flexible, easy-to-use format. MyMathLab delivers **proven results** in helping individual students succeed. It provides **engaging experiences** that personalize, stimulate, and measure learning for each student. And it comes from an **experienced partner** with educational expertise and an eye on the future.

### MyMathLab for Developmental Mathematics

Prepared to go wherever you want to take your students.

### Personalized Support for Students

#### Homework with Built-in Support

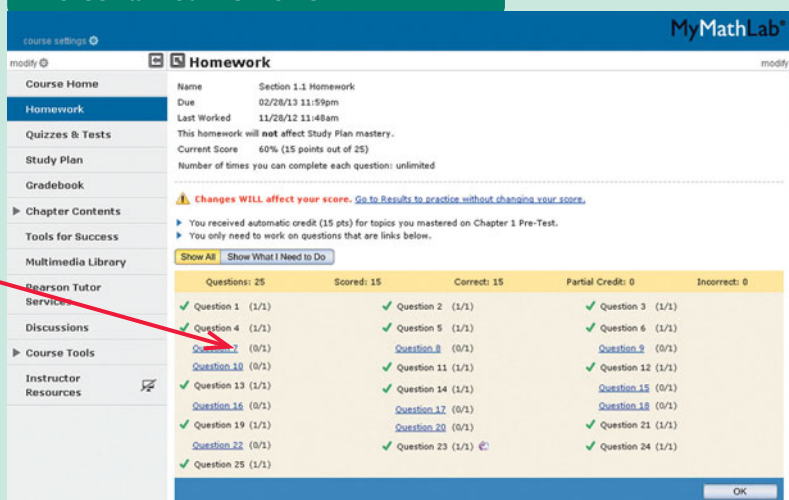


**Exercises:** The homework and practice exercises in MyMathLab are correlated to the exercises in the textbook, and they regenerate algorithmically to give students unlimited opportunities for practice and mastery. The software offers immediate, helpful feedback when students enter incorrect answers.

**Multimedia Learning Aids:** Exercises include guided solutions, sample problems, animations, videos, and eText access for extra help at point of use.

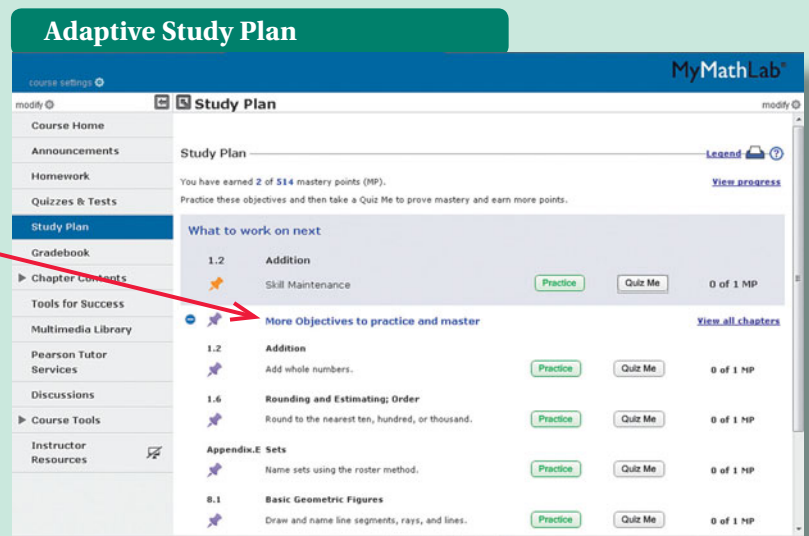
**Expert Tutoring:** Although many students describe the whole of MyMathLab as "like having your own personal tutor," students using MyMathLab do have access to live tutoring from qualified math instructors.

#### Personalized Homework



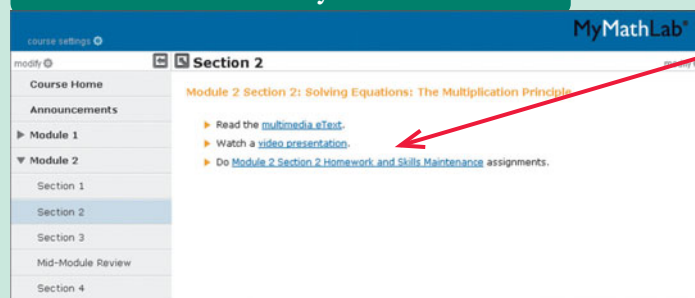
To help students achieve mastery, MyMathLab can generate **personalized homework** based on individual performance on tests or quizzes. Personalized homework allows students to focus on topics they have not yet mastered.

The **Adaptive Study Plan** makes studying more efficient and effective for every student. Performance and activity are assessed continually in real time. The data and analytics are used to provide personalized content—reinforcing concepts that target each student’s strengths and weaknesses.



## Flexible Design, Easy Start-Up, and Results for Instructors

### Customized and Ready-to-Go Courses

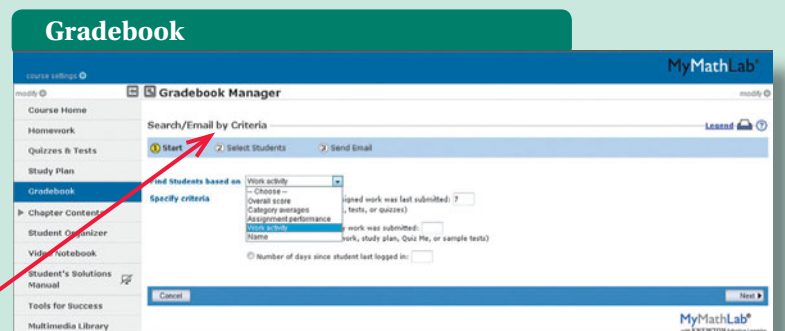


Instructors can modify the site navigation and insert their own directions on course-level landing pages; also, a custom MyMathLab course can be built that reorganizes and structures the course material by chapters, modules, units—whatever the need may be.

**Ready-to-Go courses** include preassigned homework, quizzes, and tests to make it even easier to get started. The Bittinger Ready-to-Go courses include new *Mid-Chapter Reviews* and *Reading Check Assignments*, plus a four-step Learning Path on each section-level landing page to help instructors direct students where to go and what resources to use.

The **comprehensive online gradebook** automatically tracks students’ results on tests, quizzes, and homework and in the study plan. Instructors can use the gradebook to quickly intervene if students have trouble, or to provide positive feedback on a job well done. The data within MyMathLab are easily exported to a variety of spreadsheet programs, such as Microsoft Excel.® Instructors can determine which points of data to export and then analyze the results to determine success.

New features, such as **Search/Email by criteria**, make the gradebook a powerful tool for instructors. With this feature, instructors can easily communicate with both at-risk and successful students. They can search by score on specific assignments, noncompletion of assignments within a given time frame, last login date, or overall score.



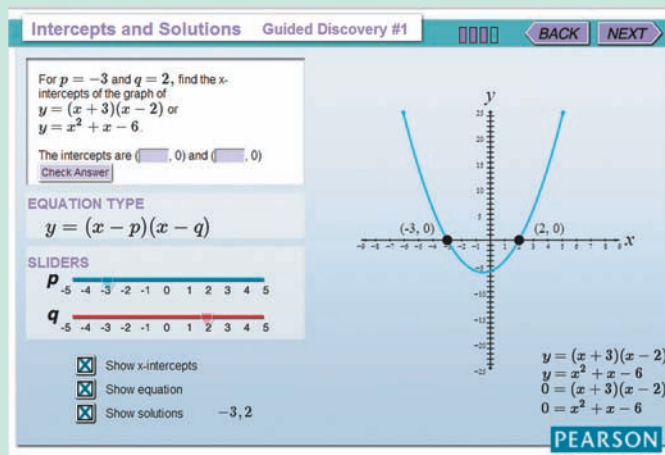
# Special Bittinger Resources

## in MyMathLab for Students and Instructors

In addition to robust course delivery, MyMathLab offers the full Bittinger eText, additional Bittinger Program features, and the entire set of instructor and student resources in one easy-to-access online location.

### New! Active Learning Figures

In MyMathLab, Active Learning Figures guide students in exploring math concepts and reinforcing their understanding. Instructors can use Active Learning Figures in class or as media assignments in MyMathLab.



### New! Four-Step Learning Path

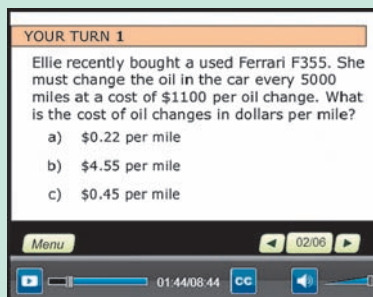
Each of the section-level landing pages in the Ready-to-Go MyMathLab course includes a Learning Path that aligns with *Your Guide to Success in Math* to link students directly to the resources they should use when they need them. This also allows instructors to point students to the best resources to use at particular times.

### New! Integrated Bittinger Video Program and MyMathGuide workbook Bittinger Video Program\*

The Video Program is available in MyMathLab and includes closed captioning and the following video types:

**New! To-the-Point Objective Videos.** These objective-based, interactive videos are incorporated into the Learning Path in MyMathLab and can be used along with the *MyMathGuide* workbook.

**Chapter Test Prep Videos.** The Chapter Test Prep Videos let students watch instructors work through step-by-step solutions to all the Chapter Test exercises from the textbook. Chapter Test Prep Videos are also available on YouTube (search using author name and book title).



**New! MyMathGuide: Notes, Practice, and Video Path workbook\***

(Printed Workbook ISBN: 978-0-321-92488-9)

This objective-based workbook for guided, hands-on learning offers vocabulary, skill, and concept review—along with problem-solving practice—with space to show work and write notes. Incorporated in the Learning Path in MyMathLab, MyMathGuide can be used together with the To-the-Point Objective Video program, instructor lectures, and the textbook. Instructors can assign To-the-Point Objective Videos in MyMathLab in conjunction with the MyMathGuide workbook.

**Equations and Solutions**

**ESSENTIALS**

An **equation** is a number sentence that says that the expressions on either side of the equals sign, =, represent the same number.

Any replacement for the variable that makes an equation true is called a **solution** of the equation. To solve an equation means to find *all* of its solutions.

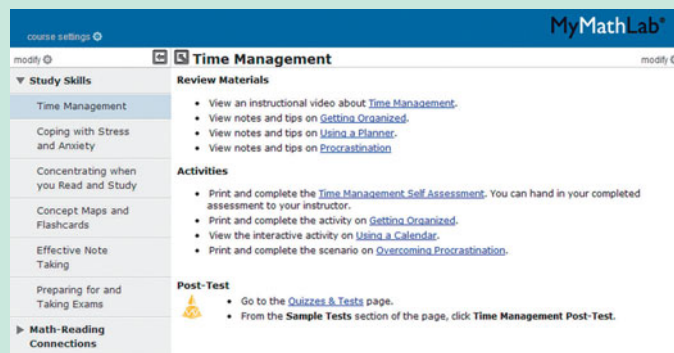
**Examples**

- $2 + 5 = 7$  The equation is *true*.
- $9 - 3 = 3$  The equation is *false*.
- $x - 8 = 11$  The equation is *neither* true nor false, because we do not know what number  $x$  represents.

**GUIDED LEARNING**

**Textbook**   **Instructor**   **Video**

| GUIDED LEARNING   | YOUR TURN  |
|---|--|
| <p><b>EXAMPLE 1</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>4 - 6 = 2</math></p> <p>The equation is false.</p>   | <p><b>YOUR TURN 1</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>5 - 9 = -4</math></p>     |
| <p><b>EXAMPLE 2</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>13 + 7 = 5 + 15</math></p> <p>The equation is true.</p>  | <p><b>YOUR TURN 2</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>12 + 4 = 7 + 7</math></p> |
| <p><b>EXAMPLE 3</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>x + 5 = 14</math></p> <p>The equation is neither true nor false, because we do not know what number <math>x</math> represents.</p> | <p><b>YOUR TURN 3</b></p> <p>Determine whether the equation is true, false, or neither.<br/> <math>7 + 3 = x</math></p>      |



**Study Skills Modules**

In MyMathLab, interactive modules address common areas of weakness, including time-management, test-taking, and note-taking skills. Additional modules support career readiness. Instructors can assign module material with a post-quiz.

# Additional Resources in MyMathLab

## For Students

### Student's Solutions Manual\*

(ISBN: 978-0-321-92474-2)

By Judy Penna

Contains completely worked-out annotated solutions for all the odd-numbered exercises in the text. Also includes fully worked-out annotated solutions for all the exercises (odd- and even-numbered) in the Mid-Chapter Reviews, the Summary and Reviews, the Chapter Tests, and the Cumulative Reviews.

## For Instructors

### Annotated Instructor's Edition\*\*

(ISBN: 978-0-321-92476-6)

This version of the text includes answers to all exercises presented in the book, as well as helpful teaching tips.

### Instructor's Resource Manual with Tests and Mini Lectures\*\*

(download only)

By Laurie Hurley

This manual includes resources designed to help both new and experienced instructors with course preparation and classroom management. This includes chapter-by-chapter teaching tips and support for media supplements. Contains two multiple-choice tests per chapter, six free-response tests per chapter, and eight final exams.

### Instructor's Solutions Manual\*\*

(download only)

By Judy Penna

This manual contains detailed, worked-out solutions to all odd-numbered exercises and brief solutions to the even-numbered exercises in the exercise sets.

### PowerPoint® Lecture Slides\*\*

(download only)

Present key concepts and definitions from the text.

To learn more about how MyMathLab combines proven learning applications with powerful assessment, visit [www.mymathlab.com](http://www.mymathlab.com) or contact your Pearson representative.

\*Printed supplements are also available for separate purchase through MyMathLab, MyPearsonStore.com, or other retail outlets. They can also be value-packed with a textbook or MyMathLab code at a discount.

\*\*Also available in print or for download from the Instructor Resource Center (IRC) on [www.pearsonhighered.com](http://www.pearsonhighered.com).



# Acknowledgments

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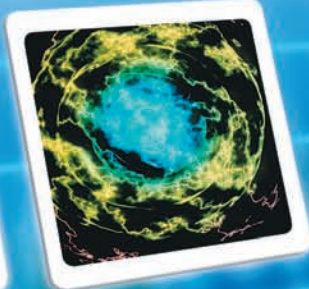
# Review of Basic Algebra

**PART 1 OPERATIONS**

- R.1** The Set of Real Numbers
- R.2** Operations with Real Numbers
- R.3** Exponential Notation and Order of Operations

**PART 2 MANIPULATIONS**

- R.4** Introduction to Algebraic Expressions
- R.5** Equivalent Algebraic Expressions
- R.6** Simplifying Algebraic Expressions
- R.7** Properties of Exponents and Scientific Notation

**Summary and Review****Test**

## STUDYING FOR SUCCESS *The Importance of Review*

- Continual review and practice sharpen skills and solidify concepts.
- Review helps you connect new material to math that you have previously studied.
- Review helps you pinpoint areas in which you need further work.

# R.1

## PART 1 OPERATIONS The Set of Real Numbers

### OBJECTIVES

- a** Use roster notation and set-builder notation to name sets, and distinguish among various kinds of real numbers.
- b** Determine which of two real numbers is greater and indicate which, using  $<$  and  $>$ ; given an inequality like  $a < b$ , write another inequality with the same meaning; and determine whether an inequality like  $-2 \leq 3$  or  $4 > 5$  is true.
- c** Graph inequalities on the number line.
- d** Find the absolute value of a real number.

### **a** SET NOTATION AND THE SET OF REAL NUMBERS

A **set** is a collection of objects. In mathematics, we usually consider sets of numbers, such as the set of **real numbers**. There is a real number for every point on the real-number line. A **subset** is a set contained within another set. We begin by examining some subsets of the set of real numbers.

The set containing the numbers  $-5$ ,  $0$ , and  $3$  can be named  $\{-5, 0, 3\}$ . It is described using the **roster method**, which lists all members of a set. We use the roster method to describe three frequently used subsets of real numbers. Note that three dots are used to indicate that the pattern continues without end.

#### NATURAL NUMBERS, WHOLE NUMBERS, AND INTEGERS

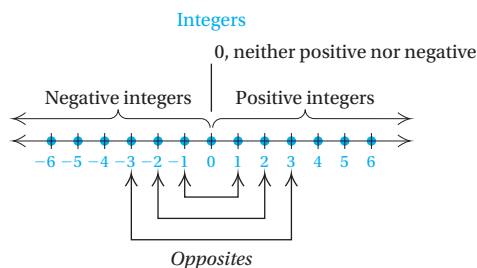
**Natural numbers** are those numbers used for counting:  $\{1, 2, 3, \dots\}$ .

**Whole numbers** are the set of natural numbers with  $0$  included:  $\{0, 1, 2, 3, \dots\}$ .

**Integers** are the set of whole numbers and their opposites:  $\{\dots, -4, -3, -2, -1, 0, 1, 2, 3, 4, \dots\}$ .

Natural numbers are also called **counting numbers**.

The integers can be illustrated on the real-number line as follows.

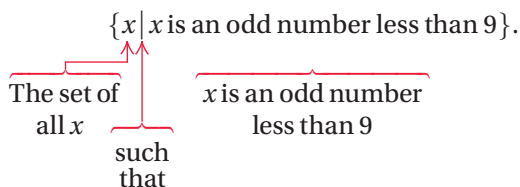


The set of integers extends infinitely to the left and to the right of  $0$ . The **opposite** of a number is found by reflecting it across the number  $0$ . Thus the opposite of  $3$  is  $-3$ . The opposite of  $-4$  is  $4$ . The opposite of  $0$  is  $0$ . We read a symbol like  $-3$  as either “the opposite of  $3$ ” or “negative  $3$ .”

The natural numbers are called **positive integers**. The opposites of the natural numbers (those to the left of 0) are called **negative integers**. Zero is neither positive nor negative.

**Do Exercises 1–3 (in the margin at right).** ▶

Other subsets of real numbers are described using **set-builder notation**. With this notation, instead of listing all members of a set, we specify conditions under which a number is in a set. For example, the set of all odd natural numbers less than 9 can be described and read as follows:



Using roster notation, we can write this set as  $\{1, 3, 5, 7\}$ .

**EXAMPLE 1** Name the set consisting of the first six even whole numbers using both roster notation and set-builder notation.

Roster notation:  $\{0, 2, 4, 6, 8, 10\}$

Set-builder notation:  $\{x \mid x \text{ is one of the first six even whole numbers}\}$

**Do Exercise 4.** ▶

We can now describe the set of **rational numbers**.

### RATIONAL NUMBERS

A **rational number** can be expressed as an integer divided by a nonzero integer. The set of rational numbers is

$$\left\{ \frac{p}{q} \mid p \text{ is an integer, } q \text{ is an integer, and } q \neq 0 \right\}.$$

Rational numbers are numbers whose decimal representation either terminates or has a repeating block of digits.

The following are examples of rational numbers:

$$\frac{5}{8}, \frac{12}{-7}, \frac{-17}{15}, \frac{-9}{7}, \frac{39}{1}, \frac{0}{6}$$

Note that  $\frac{39}{1} = 39$ . Thus the set of rational numbers contains the integers. Using long division, we can write a fraction in decimal notation:

$$\frac{5}{8} = \underbrace{0.625}_{\text{Terminating}} \quad \text{and} \quad \frac{6}{11} = \underbrace{0.545454 \dots}_{\text{Repeating}} = 0.\overline{54}.$$

The bar in  $0.\overline{54}$  indicates the repeating block of digits in decimal notation.

**Do Exercises 5 and 6.** ▶

Find the opposite of each number.

- 9
- 6
- 0

- Name the set consisting of the first seven odd whole numbers using both roster notation and set-builder notation.

Convert each fraction to decimal notation by long division and determine whether it is terminating or repeating.

- $\frac{11}{16}$

**GS**

- $\frac{14}{3}$

$$\begin{array}{r} \square .6 \\ 3 \overline{)14.0} \\ \underline{12} \phantom{0} \\ 20 \phantom{0} \\ \underline{18} \phantom{0} \\ 2 \phantom{0} \end{array}$$

$$\begin{array}{r} 12 \\ \underline{12} \\ 20 \\ \underline{18} \\ 2 \phantom{0} \end{array}$$

← The remainder repeats.

Thus,  $\frac{14}{3} = \square.\overline{6}$ . The decimal notation is  $\square$ .

terminating/  
repeating

### Answers

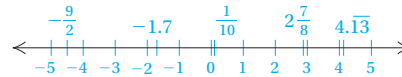
- 9
- 6
- 0
- $\{1, 3, 5, 7, 9, 11, 13\}$ ;  $\{x \mid x \text{ is one of the first seven odd whole numbers}\}$
- 0.6875; terminating
- 4.6; repeating

*Guided Solution:*

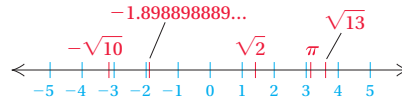
- 4, 2, 4, repeating



The real-number line has a point for every rational number.



However, there are many points on the line for which there is no rational number. These points correspond to what are called **irrational numbers**.

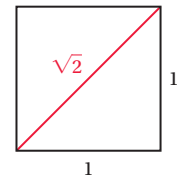


Numbers like  $\pi$ ,  $\sqrt{2}$ ,  $-\sqrt{10}$ ,  $\sqrt{13}$ , and  $-1.898898889\dots$  are examples of irrational numbers. The decimal notation for an irrational number *neither* terminates *nor* repeats. Recall that decimal notation for rational numbers either terminates or has a repeating block of digits.

### IRRATIONAL NUMBERS

**Irrational numbers** are numbers whose decimal representation neither terminates nor has a repeating block of digits. They cannot be represented as the quotient of two integers.

The irrational number  $\sqrt{2}$  (read “the square root of 2”) is the length of the diagonal of a square with sides of length 1. It is also the number that, when multiplied by itself, gives 2. No rational number can be multiplied by itself to get 2, although some approximations come close:



1.4 is an *approximation* of  $\sqrt{2}$  because  $(1.4)^2 = (1.4)(1.4) = 1.96$ ;

1.41 is a better approximation because  $(1.41)^2 = (1.41)(1.41) = 1.9881$ ;

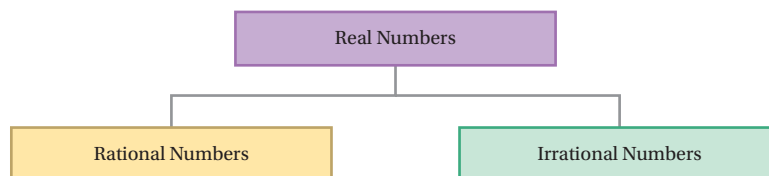
1.4142 is an even better approximation because  $(1.4142)^2 = (1.4142)(1.4142) = 1.99996164$ .

We say that 1.4142 is a rational approximation of  $\sqrt{2}$  because

$$(1.4142)^2 = 1.99996164 \approx 2.$$

The symbol  $\approx$  means “is approximately equal to.” We can find rational approximations for square roots and other irrational numbers using a calculator.

The set of all rational numbers, combined with the set of all irrational numbers, gives us the set of **real numbers**.

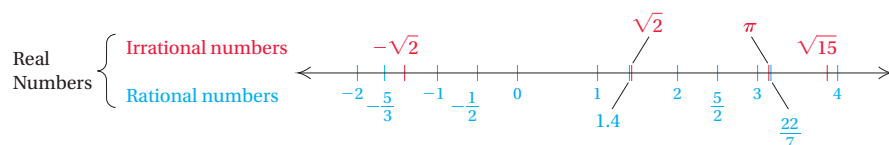


## REAL NUMBERS

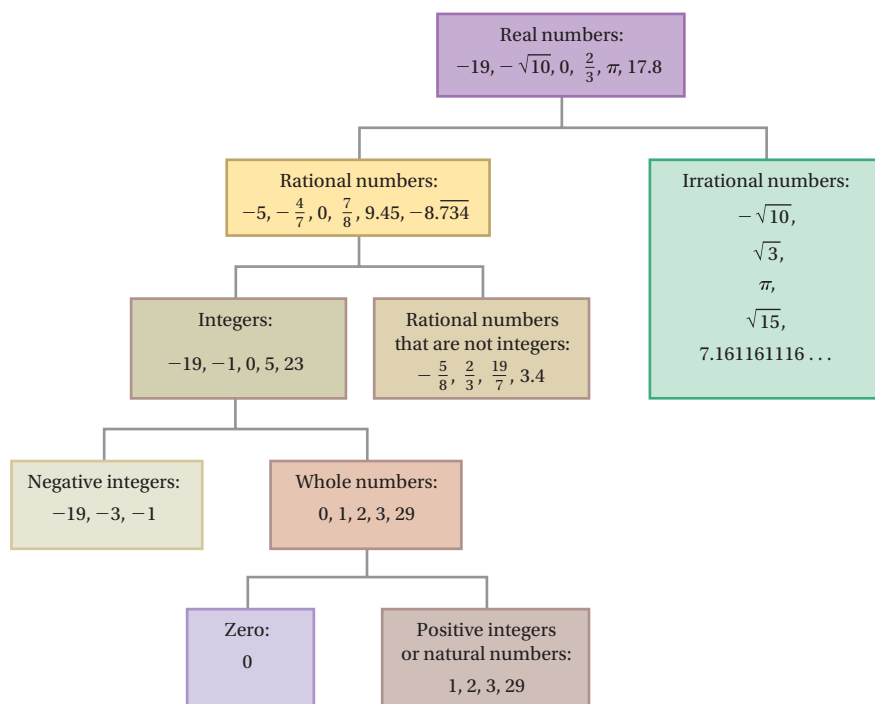
The set of **real numbers** is

$$\{x \mid x \text{ is a rational number or } x \text{ is an irrational number}\}.$$

Every point on the number line represents some real number and every real number is represented by some point on the number line.



The following figure shows the relationships among various sets of real numbers.



Do Exercise 7. ►

7. Given the numbers

20, -10, -5.34, 18.999,

$\frac{11}{45}$ ,  $\sqrt{7}$ ,  $-\sqrt{2}$ ,  $\sqrt{16}$ , 0,  $-\frac{2}{3}$ ,

9.34334333433334 . . . :

a) Name the natural numbers.

b) Name the whole numbers.

c) Name the integers.

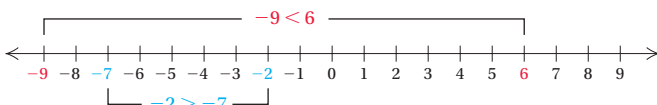
d) Name the irrational numbers.

e) Name the rational numbers.

f) Name the real numbers.

## b ORDER FOR THE REAL NUMBERS

Real numbers are named in order on the number line, with larger numbers named further to the right. For any two numbers on the line, the one to the left is less than the one to the right.



We use the symbol  $<$  to mean “**is less than.**” The sentence  $-9 < 6$  means “-9 is less than 6.” The symbol  $>$  means “**is greater than.**” The sentence  $-2 > -7$  means “-2 is greater than -7.” Sentences containing  $<$  or  $>$  are called **inequalities**.

**Answer**

7. (a) 20,  $\sqrt{16}$ ; (b) 20,  $\sqrt{16}$ , 0;

(c) 20, -10,  $\sqrt{16}$ , 0; (d)  $\sqrt{7}$ ,  $-\sqrt{2}$ ,

9.34334333433334 . . . ; (e) 20, -10, -5.34, 18.999,

$\frac{11}{45}$ ,  $\sqrt{16}$ , 0,  $-\frac{2}{3}$ ; (f) 20, -10, -5.34, 18.999,  $\frac{11}{45}$ ,

$\sqrt{7}$ ,  $-\sqrt{2}$ ,  $\sqrt{16}$ , 0,  $-\frac{2}{3}$ , 9.34334333433334 . . .

Insert  $<$  or  $>$  for  $\square$  to write a true sentence.

8.  $-5 \square -4$

9.  $-\frac{1}{4} \square -\frac{1}{2}$

10.  $87 \square 67$

11.  $-9.8 \square -4\frac{2}{3}$

12.  $6.78 \square -6.77$

13.  $-\frac{4}{5} \square -0.86$

14.  $\frac{14}{29} \square \frac{17}{32}$

15.  $-\frac{12}{13} \square -\frac{14}{15}$

16.  $1.8 \square 1.08$

Write a different inequality with the same meaning.

17.  $x > 6$

18.  $-4 < 7$

Determine whether each of the following is true or false.

19.  $6 \geq -9.4$

20.  $-18 \leq -18$

21.  $-7.6 \leq -10\frac{4}{5}$

22.  $-\frac{24}{27} \geq -\frac{25}{28}$

**Answers**

8.  $<$  9.  $>$  10.  $>$  11.  $<$  12.  $>$   
 13.  $>$  14.  $<$  15.  $>$  16.  $>$  17.  $6 < x$   
 18.  $7 > -4$  19. True 20. True  
 21. False 22. True

**EXAMPLES** Use either  $<$  or  $>$  for  $\square$  to write a true sentence.

2.  $4 \square 9$  Since 4 is to the left of 9, 4 is less than 9, so  $4 < 9$ .

3.  $-8 \square 3$  Since  $-8$  is to the left of 3, we have  $-8 < 3$ .

4.  $7 \square -12$  Since 7 is to the right of  $-12$ , then  $7 > -12$ .

5.  $-21 \square -5$  Since  $-21$  is to the left of  $-5$ , we have  $-21 < -5$ .

6.  $4.79 \square 4.97$  Since 4.79 is to the left of 4.97, we have  $4.79 < 4.97$ .

7.  $-2.7 \square -\frac{3}{2}$  Since  $-\frac{3}{2} = -1.5$  and  $-2.7$  is to the left of  $-1.5$ , we have  $-2.7 < -\frac{3}{2}$ .

8.  $\frac{5}{8} \square \frac{7}{11}$  We convert to decimal notation ( $\frac{5}{8} = 0.625$  and  $\frac{7}{11} = 0.6363\dots$ ) and compare. Thus,  $\frac{5}{8} < \frac{7}{11}$ .

**Do Exercises 8–16.**

All positive real numbers are greater than zero and all negative real numbers are less than zero.

If  $x$  is a positive real number, then  $x > 0$ .  
 If  $x$  is a negative real number, then  $x < 0$ .

Note that  $-8 < 5$  and  $5 > -8$  are both true. Every true inequality yields another true inequality if we interchange the numbers or variables and reverse the direction of the inequality sign.

$a < b$  also has the meaning  $b > a$ .

**EXAMPLES** Write a different inequality with the same meaning.

9.  $a < -5$  The inequality  $-5 > a$  has the same meaning.

10.  $-3 > -8$  The inequality  $-8 < -3$  has the same meaning.

**Do Exercises 17 and 18.**

Expressions like  $a \leq b$  and  $b \geq a$  are also **inequalities**. We read  $a \leq b$  as " $a$  is less than or equal to  $b$ ." We read  $a \geq b$  as " $a$  is greater than or equal to  $b$ ." If  $a$  is nonnegative, then  $a \geq 0$ .

**EXAMPLES** Determine whether each of the following is true or false.

11.  $-8 \leq 5.7$  True since  $-8 < 5.7$  is true.

12.  $-8 \leq -8$  True since  $-8 = -8$  is true.

13.  $-7 \geq 4\frac{1}{3}$  False since neither  $-7 > 4\frac{1}{3}$  nor  $-7 = 4\frac{1}{3}$  is true.

14.  $-\frac{2}{3} \geq -\frac{5}{4}$  True since  $-\frac{2}{3} = -0.666\dots$  and  $-\frac{5}{4} = -1.25$  and  $-0.666\dots > -1.25$ .

**Do Exercises 19–22.**

## C GRAPHING INEQUALITIES ON THE NUMBER LINE

A replacement that makes an inequality true is called a **solution**. The set of all solutions is called the **solution set**. A **graph** of an inequality is a drawing that represents its solution set.

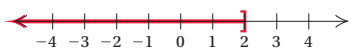
**EXAMPLE 15** Graph the inequality  $x > -3$  on the number line.

The solutions consist of all real numbers greater than  $-3$ , so we shade all numbers greater than  $-3$ . Since  $-3$  is not a solution, we use a parenthesis at  $-3$ . The graph represents the solution set  $\{x \mid x > -3\}$ .



**EXAMPLE 16** Graph the inequality  $x \leq 2$  on the number line.

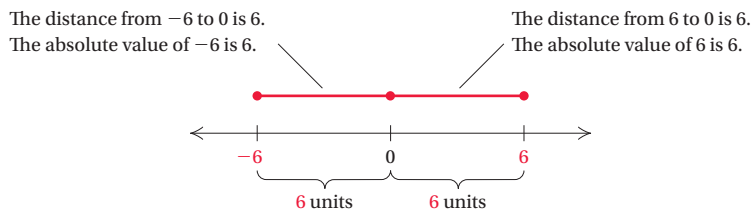
We make a drawing that represents the solution set  $\{x \mid x \leq 2\}$ . The graph consists of 2 as well as the numbers less than 2. We shade all numbers to the left of 2 and use a bracket at 2 to indicate that it is also a solution.



Do Exercises 23–26. ►

## d ABSOLUTE VALUE

We call the distance of a number from 0 on the number line the **absolute value** of the number. Since distance is always a nonnegative number, the absolute value of a number is always greater than or equal to 0.



### ABSOLUTE VALUE

The **absolute value** of a number is its distance from 0 on the number line. We use the symbol  $|x|$  to represent the absolute value of a number  $x$ .

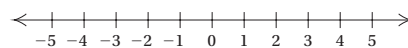
**EXAMPLES** Find the absolute value.

17.  $|-7|$  The distance of  $-7$  from 0 is 7, so  $|-7|$  is 7.  
 18.  $|12|$  The distance of 12 from 0 is 12, so  $|12|$  is 12.  
 19.  $|0|$  The distance of 0 from 0 is 0, so  $|0|$  is 0.  
 20.  $\left|\frac{4}{5}\right| = \frac{4}{5}$   
 21.  $|-3.86| = 3.86$

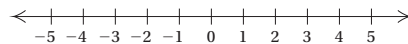
Do Exercises 27–30. ►

Graph each inequality.

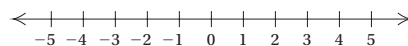
23.  $x > -1$



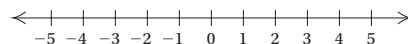
24.  $x \leq 5$



25.  $0 < x$



26.  $-\frac{5}{2} \geq x$



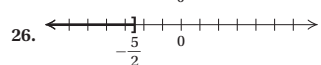
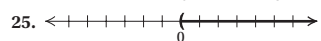
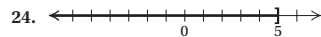
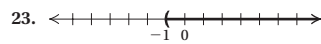
Find the absolute value.

**GS** 27.  $|2|$   
 The distance of 2 from 0 is , so  $|2|$  is .

28.  $\left|-\frac{1}{4}\right|$       29.  $\left|\frac{3}{2}\right|$

30.  $|-2.3|$

### Answers



27. 2    28.  $\frac{1}{4}$     29.  $\frac{3}{2}$     30. 2.3

Guided Solution:

27. 2, 2

 Reading Check

Choose from the column on the right the set of numbers that matches the description.

- |                                    |  |
|------------------------------------|--|
| <b>RC1.</b> ___ Natural numbers    | <b>a)</b> $\{\dots, -3, -2, -1, 0, 1, 2, 3, \dots\}$   |
| <b>RC2.</b> ___ Whole numbers      | <b>b)</b> $\{0, 1, 2, 3, \dots\}$  |
| <b>RC3.</b> ___ Integers           | <b>c)</b> $\{1, 2, 3, 4, \dots\}$  |
| <b>RC4.</b> ___ Rational numbers   | <b>d)</b> $\{x \mid x \text{ is a rational number or } x \text{ is an irrational number}\}$                  |
| <b>RC5.</b> ___ Irrational numbers | <b>e)</b> $\{x \mid x \text{ cannot be represented as the quotient of two integers}\}$                       |
| <b>RC6.</b> ___ Real numbers       | <b>f)</b> $\left\{\frac{p}{q} \mid p \text{ is an integer, } q \text{ is an integer, and } q \neq 0\right\}$ |

**a** Given the numbers  $-6, 0, 1, -\frac{1}{2}, -4, \frac{7}{9}, 12, -\frac{6}{5}, 3.45, 5\frac{1}{2}, \sqrt{3}, \sqrt{25}, -\frac{12}{3}, 0.131331333133331\dots$ :

- |                              |                            |                                 |
|------------------------------|----------------------------|---------------------------------|
| 1. Name the natural numbers. | 2. Name the whole numbers. | 3. Name the rational numbers.   |
| 4. Name the integers.        | 5. Name the real numbers.  | 6. Name the irrational numbers. |

Given the numbers  $-\sqrt{5}, -3.43, -11, 12, 0, \frac{11}{34}, -\frac{7}{13}, \pi, -3.565665666566665\dots$ :

- |                                |                                  |                            |
|--------------------------------|----------------------------------|----------------------------|
| 7. Name the whole numbers.     | 8. Name the natural numbers.     | 9. Name the integers.      |
| 10. Name the rational numbers. | 11. Name the irrational numbers. | 12. Name the real numbers. |

Use roster notation to name each set.

- |   |  |  |
|---|--|--|
| 13. The set of all letters in the word "math"     | 14. The set of all letters in the word "solve" | 15. The set of all positive integers less than 13      |
| 16. The set of all odd whole numbers less than 13 | 17. The set of all even natural numbers        | 18. The set of all negative integers greater than $-4$ |



Use set-builder notation to name each set.

19.  $\{0, 1, 2, 3, 4, 5\}$

20.  $\{4, 5, 6, 7, 8, 9, 10\}$

21. The set of all rational numbers

22. The set of all real numbers

23. The set of all real numbers greater than  $-3$

24. The set of all real numbers less than or equal to 21

**b**

Use either  $<$  or  $>$  for  $\square$  to write a true sentence.

25.  $13 \square 0$

26.  $18 \square 0$

27.  $-8 \square 2$

28.  $7 \square -7$

29.  $-8 \square 8$

30.  $0 \square -11$

31.  $-8 \square -3$

32.  $-6 \square -3$

33.  $-2 \square -12$

34.  $-7 \square -10$

35.  $-9.9 \square -2.2$

36.  $-13\frac{1}{5} \square \frac{11}{250}$

37.  $37\frac{1}{5} \square -1\frac{67}{100}$

38.  $-13.99 \square -8.45$

39.  $\frac{6}{13} \square \frac{13}{25}$

40.  $-\frac{14}{15} \square -\frac{27}{53}$

Write a different inequality with the same meaning.

41.  $-8 > x$

42.  $x < 7$

43.  $-12.7 \leq y$

44.  $10\frac{2}{3} \geq t$

Write true or false.

45.  $6 \leq -6$

46.  $-7 \leq -7$

47.  $5 \geq -8.4$

48.  $-11 \geq -13\frac{1}{2}$