

FROM THE MAKERS OF THE ACT®

THE  
**OFFICIAL**  
**ACT**®

**MATHEMATICS GUIDE**  
**THIRD EDITION**

**A Step-by-Step Guide Outlining the Preparation for the ACT®**

**FEATURES**

- Review the entire ACT® mathematics test so you'll know what to expect
- Familiarize yourself with the types of math questions found on the ACT®
- Understand the math topics within the problems you'll solve while taking the mathematics test
- Includes 100s of official ACT® questions with answers and explanations

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THE  
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MATHEMATICS GUIDE  
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**ACT**  
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# Introduction

So you want to do well on the ACT mathematics test. That's a good goal to have! Whether you've already taken the test once or are planning to do so in the near or even distant future, this book will help you achieve your goal. There are three major factors that will determine how well you do on the ACT math test:

- Focus
- Effort
- Guidance

You need to be focused and diligent in your studies and preparation for the ACT mathematics test. There is no getting around that. You need to put the time and effort into fully practicing the skills the test will be looking for. If you are reading this book, it can be assumed that you are focused on achieving your goal of success and that you are willing to put the necessary time and effort into making it happen.

The third factor, guidance, is where this book comes into play. Guidance is difficult to supply to yourself. This book covers just about every math topic that you're likely to see on the ACT mathematics test, so by going through this book, you'll know what to expect on test day.

The plan is simple. Start with [chapter 1](#) and become familiar with the reporting categories on the test, which are the foundation for your math score. Continue with [chapters 2](#) through [6](#) and refresh your math progressively while working the practice ACT questions that accompany most topics. Be sure to note anything you struggle with to

review later. Finally, work through [chapter 7](#), which includes practice ACT questions. Review [chapter 8](#) for a detailed and thorough breakdown of the solution to each question.

If you struggle with certain math topics, you're not alone, but now you have an edge: you know the scope of the ACT math test and which topics you need to review. Most students who score well on the ACT had to practice first, and this is something that you can do. Almost no one gets a perfect score, but with the guidance in this book, you can score well enough to be a competitive applicant to a good university.

You definitely want to pick up the other ACT subject guides, and you'll eventually want to take at least one full-length practice exam from *The Official ACT Prep Guide*, but this is a good start for the math. You can and will succeed with your goal of doing well on the ACT math test. You provide the focus and the effort, and this book will provide the guidance. So read on, and let's get started.

# Chapter 1:

## The ACT Math Test

The ACT mathematics test is a 45-question, 50-minute test designed to assess the mathematical reasoning skills that you've acquired in courses taken up to the beginning of grade 12. All questions are self-contained.

The questions cover a wide variety of concepts, techniques, and procedures that emphasize the major content areas requisite to successful performance in entry-level courses in college mathematics. Some questions require computation, but the questions are designed to emphasize your ability to reason mathematically, not your ability to compute numbers or recall complex formulas.

You may use a calculator. See [www.act.org/calculator-policy.html](http://www.act.org/calculator-policy.html) for details about models and features that are permitted or prohibited.

## Reporting Categories: Score Reporting

Nine scores are reported for the mathematics test: a total test score based on all 41 scored questions and eight reporting category scores based on specific mathematical knowledge and skills. There are 4 items that are not scored. The approximate number of scored questions and percentage of the test devoted to each reporting category is shown in [Table 1.1](#).

**Table 1.1:** Number of Questions per Reporting Category

<b>Reporting Category/Reported Score</b>	<b>Number of Questions</b>	<b>Percentage of Test</b>
Integrating Essential Skills	8	20
Preparing for Higher Mathematics	33	80
Number and Quantity	4-5	10-12
Algebra	7-8	17-20
Functions	7-8	17-20
Geometry	7-8	17-20
Statistics and Probability	5-6	12-15
Modeling	$\geq 8$	$\geq 20$
<b>Total Math Test Score</b>	<b>41</b>	<b>100</b>

## Reporting Categories: Topic Overview

**Integrating Essential Skills** measures how well you can synthesize and apply your understanding and skills from previously learned concepts to solve more complex problems. These questions ask you to address topics such as rates and percentages; proportional relationships; area, surface area, and volume; average and median; and the expression of numbers in different ways. You will be asked to solve nonroutine problems that involve combining skills in longer chains of steps in more varied contexts, while understanding conceptual connections and demonstrating fluency of skills.

**Preparing for Higher Mathematics** covers mathematics that you recently learned, starting with the use of algebra

as a general way of expressing and solving equations. This category has its own reported score and is divided into five discrete categories, each with its own reported score:

- **Number and Quantity** asks about real and complex number systems. You will be asked to apply your understanding and fluency with rational numbers and the four basic operations (addition, subtraction, multiplication, and division) to irrational numbers by manipulating rational numbers and delving deeper into properties of the real number system. You will be asked to apply your knowledge of integer exponents to rational exponents. Questions also involve vectors and matrices, which can be treated as number systems with properties, operations, and applications.
- **Algebra** asks you to solve, graph, and model different types of expressions. You will be asked to interpret and use various equations based on linear, polynomial, radical, and exponential relationships in the context of equations and inequalities. Questions will ask you to apply your understanding of expressions to strategically solve problems, and you will be asked to apply polynomial relationships in applications to create expressions, equations, and inequalities that represent problems and constraints in real-world contexts.
- **Functions** questions are based on the definition, notation, representation, and application of functions in linear, radical, piecewise, polynomial, and logarithmic forms. These questions provide a framework for modeling real-world phenomena, and you will be asked to interpret the characteristics of a function in the context of a problem while recognizing the difference between a model and reality. You will also be asked to manipulate and translate functions as well as interpret and use key features of graphs.

- **Geometry** asks you to apply your knowledge of shapes and solids to spatial concepts that include congruence and similarity relationships and surface area and volume measurements. You will be asked to apply your understanding of geometric objects to model and solve problems as well as find missing values in triangles, circles, and other figures. You will also be asked to apply trigonometric ratios as functions of right triangles and apply these concepts to the coordinate plane. Questions may also ask about trigonometric concepts of non-right triangles based on the law of sines and the law of cosines.
- **Statistics and Probability** is based on the distribution of data. You will be asked about data collection methods and relationship models in bivariate data. You will also be asked to calculate probabilities by recognizing the related sample spaces.

**Modeling** represents all questions that involve producing, interpreting, understanding, evaluating, and improving models, which are representations of complex mathematical concepts. This category is an overall measure of how well you use modeling skills across mathematical topics. Each Modeling question is also counted in other appropriate reporting categories; thus, the Modeling category is an overall measure of how well you use modeling skills across mathematical topics.

## **Tips for Taking the Mathematics Test**

### **If you use a calculator, use it wisely.**

All of the mathematics problems can be solved without a calculator. Many of the problems are best done without a calculator. Use good judgment in deciding when, and when not, to use a calculator. For example, for some problems you may wish to do scratch work to clarify your thoughts on the question before you begin using a calculator to do computations.

### **Solve the problem.**

To work out solutions to the problems, you will usually do scratch work in the space provided. You may wish to glance over the answer choices after reading the questions. However, working backwards from all four answer choices can take a lot of time and may not be effective.

### **Find your solution among the answer choices.**

Once you have solved the problem, look for your answer among the choices. If your answer is not included among the choices, carefully reread the problem to see whether you missed important information. Pay careful attention to the question being asked. If an equation is to be selected, check to see whether the equation you think is best can be transformed into one of the answer choices provided.

**Make sure you answer the question.**

The solutions to many questions on the test will involve several steps. Make sure your answer accounts for all the necessary steps. Frequently, an answer choice is an intermediate result, not the final answer.

**Make sure your answer is reasonable.**

Sometimes an error in computation will result in an answer that is not practically possible for the situation described. Always think about your answer to determine whether it is reasonable.

**Check your answer.**

You may arrive at an incorrect solution by making common errors in the problem-solving process. If there is time remaining before the end of the mathematics test, it is important that you reread the questions and check your answers to make sure they are correct.

## Chapter 2: Number and Quantity

**Number and Quantity** tests your ability to apply real and complex number systems in various forms, including integer and rational exponents, vectors, and matrices.

### Real Numbers

A **real number** is any number that appears on the number line, whether positive, negative, or zero. Real numbers include all rational and irrational numbers.

An **integer** is any number, positive, negative, or zero, that can be written without a fractional or decimal component.

A **whole number** is any positive integer and doesn't include zero.

Numbers that do not exist on the real number line are discussed later in this chapter.

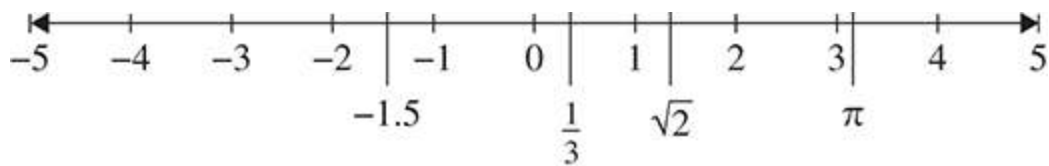
A **rational number** is any number or fraction that can be expressed as a terminating or repeating decimal. For example, the fraction  $\frac{1}{4}$  can be expressed as the decimal 0.25, which both terminates and expresses the true value of the decimal. The fraction  $\frac{1}{3}$  can be expressed as the decimal  $0.\overline{33}$ , which doesn't terminate but is considered rational because it repeats. The fraction  $\frac{7}{22}$ , equivalent to  $0.3\overline{18}$ , is also considered rational because the 18 in the decimal repeats.

A **non-rational** or **irrational number** is a real number that cannot be written as a fraction or a terminating or

repeating decimal. Examples of non-rational numbers are  $\sqrt{2}$  and  $\pi$ .

## Number Line and Absolute Value

The **number line** represents the spectrum of all real numbers and symbolically extends infinitely in both directions.

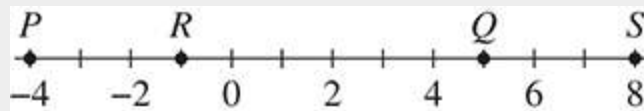


**Absolute value** represents an expression's distance from 0 on the number line. Absolute value is always positive, because a distance is always positive. Because -5 is 5 units from 0, the absolute value of -5, written as  $|-5|$ , is 5.

You can take the negative of an absolute value, but the absolute value itself is always positive. For example,  $-|-7|$  is the same thing as  $-(+7)$ , which equals -7. Take the calculations step by step:  $|-7| = 7$ , and the negative of 7 is -7.

## Reporting Category Quiz: Integrating Essential Skills

1. Which of the following lists orders  $\frac{1}{3}$ , 0.28,  $\frac{2}{5}$ ,  $\frac{3}{8}$ , 0.37, and  $\frac{3}{10}$  from least to greatest?
- A. 0.28,  $\frac{3}{10}$ ,  $\frac{1}{3}$ , 0.37,  $\frac{3}{8}$ ,  $\frac{2}{5}$
- B. 0.28,  $\frac{3}{10}$ ,  $\frac{1}{3}$ ,  $\frac{3}{8}$ , 0.37,  $\frac{2}{5}$
- C. 0.28,  $\frac{3}{10}$ ,  $\frac{3}{8}$ ,  $\frac{2}{5}$ ,  $\frac{1}{3}$ , 0.37
- D. 0.28, 0.37,  $\frac{3}{10}$ ,  $\frac{1}{3}$ ,  $\frac{3}{8}$ ,  $\frac{2}{5}$
2.  $|5(-4)+3(6)| = ?$
- A. -2
- B. 2
- C. 10
- D. 38
3. On the real number line given, with coordinates as labeled, an object moves according to the following set of instructions: From point  $P$  the object moves right to  $Q$ , then left to  $R$ , then right to  $S$ , and finally left until it returns to its original position at  $P$ . What is the closest estimate of the total length, in coordinate units, of the movements this object makes?



A. 12

B. 16

C. 24

D. 36

4. If the inequality  $|a| > |b|$  is true, then which of the following **must** be true?

A.  $a > b$

B.  $a = b$

C.  $a < b$

D.  $a \neq b$

**DO YOUR FIGURING HERE.**

## Reporting Category Quiz: Preparing for Higher Mathematics | Number and Quantity

5. A ticket for a movie at the Hazelnut Cinema costs \$12. Latoya treats her younger brother to a movie at the Hazelnut Cinema. She gives him  $\frac{1}{2}$  the money she brought with her, for his ticket and a candy. When he asks to play a video game, she gives him \$3. That leaves Latoya exactly enough money to buy her own ticket. How much money did Latoya bring with her?
- A. \$15
  - B. \$24
  - C. \$27
  - D. \$30
6. Vehicle A averages 19 miles per gallon of gasoline, and Vehicle B averages 37 miles per gallon of gasoline. At these rates, how many more gallons of gasoline does Vehicle A need than Vehicle B to make a 1,406-mile trip?
- A. 28
  - B. 36
  - C. 38
  - D. 56
7. Melissa knows that 30 miles per hour is equivalent to 44 feet per second. If Melissa drives at a speed of 70 miles per hour, which of the following is closest to her speed in feet per second?
- A. 31

- B. 48
- C. 103
- D. 127

**DO YOUR FIGURING HERE.**

### **Multiples, Factors, and Prime Numbers**

A **multiple** is an integer that results from the product of two other integers. For example, to find multiples of 7, multiply 7 by  $-2$ ,  $-1$ ,  $0$ ,  $1$ ,  $2$ ,  $3$ , and so on, resulting in  $-14$ ,  $-7$ ,  $0$ ,  $7$ ,  $14$ ,  $21$ , and so on. Note that every integer is a multiple of itself: 23 is a multiple of 23.

A **factor** is an integer that results from dividing two other integers. For example, to find the factors of 30, find the pairs of numbers that multiply to 30:  $\pm 5$  and  $\pm 6$ ,  $\pm 3$  and  $\pm 10$ ,  $\pm 2$  and  $\pm 15$ , and  $\pm 1$  and  $\pm 30$ . Note that 1 is a factor of every integer, and every integer is a factor of itself. For example, factors of 52 include 1 and 52.

A **prime number** is a whole number greater than 1 that has exactly two positive factors: 1 and itself. For example, 13 is a prime number, because its only positive factors are 1 and 13. Note that 2 is the only even prime number; 1 and 0 are not considered prime.

A **composite number** is a whole number greater than 1 that isn't prime; that is, it has more than two positive factors. For example, 12 is a composite number, because its positive factors are 1, 2, 3, 4, 6, and 12. Prime factorization is the factoring of a composite number to its primes, including duplicates. For example, the prime factorization

of 30 is  $2 \times 3 \times 5$ . Note that prime factorization doesn't include 1 as a factor.

These composite numbers can be prime factored:

1. 20

2. 36

3. 48

Results:

1.  $20 = 2 \times 2 \times 5$

2.  $36 = 2 \times 2 \times 3 \times 3$

3.  $48 = 2 \times 2 \times 2 \times 2 \times 3$

## Reporting Category Quiz: Integrating Essential Skills

8. Mr. Dietz is a teacher whose salary is \$78,000 for this school year, which has 200 days. In Mr. Dietz's school district, substitute teachers are paid \$125 per day. If Mr. Dietz takes a day off without pay and a substitute teacher is paid to teach Mr. Dietz's classes, how much less does the school district pay in salary by paying a substitute teacher instead of paying Mr. Dietz for that day?
- A. \$125
  - B. \$257
  - C. \$265
  - D. \$390
9. Nick needs to order 500 pens from his supplier. The catalog shows that these pens come in cases of 24 boxes with 10 pens in each box. Nick knows that he may **not** order partial cases. What is the fewest number of cases he should order?
- A. 2
  - B. 3
  - C. 21
  - D. 50
10. What is the least common multiple of 20, 30, and 70?
- A. 40
  - B. 120
  - C. 420

D. 42,000

11. Mary takes 2 medications throughout the day and night. One medication is to be taken every 6 hours and the other is to be taken every 4 hours. Mary begins taking both medications at 7:00 a.m. and takes both medications on schedule. How many hours later will it be when she next takes both medications at the same time?

A. 6

B. 10

C. 12

D. 24

12. For integers  $a$  and  $b$  such that  $ab = 8$ , which of the following is **not** a possible value of  $a$ ?

A. -8

B. -6

C. 1

D. 2

**DO YOUR FIGURING HERE.**

## ***Fractions***

A **fraction** is a numerical quantity that is not a whole number, such as  $\frac{5}{8}$ . The **reciprocal** of a fraction is the switching of its numerator and denominator. For example,

the reciprocal of  $\frac{2}{5}$  is  $\frac{5}{2}$ . Placing a 1 on top of a fraction yields its reciprocal. For example,  $\frac{1}{\frac{5}{7}} = \frac{1}{1} \left( \frac{7}{5} \right) = \frac{7}{5}$ .

- Add and subtract fractions by giving them common denominators:  $\frac{5}{8} + \frac{3}{4} \rightarrow \frac{5}{8} + \frac{3(2)}{4(2)} \rightarrow \frac{5}{8} + \frac{6}{8} = \frac{11}{8}$ .
- Multiply fractions by multiplying the numerators then the denominators:  $\frac{2}{3} \times \frac{5}{7} \rightarrow \frac{2 \times 5}{3 \times 7} = \frac{10}{21}$
- Divide fractions by multiplying the first fraction by the reciprocal of the second fraction:  $\frac{4}{5} \div \frac{1}{2} \rightarrow \frac{4}{5} \times \frac{2}{1} = \frac{8}{5}$ .

If an ACT mathematics test question involves multiplying fractions that have large numerators or denominators, you can often simplify the math work by reducing and cancelling the numbers before multiplying. In this example, the numerator 500 is a multiple of the denominator 250, so reducing these numbers before multiplying saves math work:  $\frac{500}{5} \times \frac{3}{250} \rightarrow \frac{2}{5} \times \frac{3}{1} = \frac{6}{5}$ .

## Reporting Category Quiz: Integrating Essential Skills

13. Of the 804 graduating seniors in a certain high school, approximately  $\frac{2}{5}$  are going to college and approximately  $\frac{1}{4}$  of those going to college are going to a state university. Which of the following is the closest estimate for how many of the graduating seniors are going to a state university?
- A. 80
  - B. 160
  - C. 200
  - D. 280
14. What is the least common denominator when adding the simplified fractions  $\frac{a}{2}$ ,  $\frac{b}{3}$ ,  $\frac{c}{9}$ , and  $\frac{d}{15}$ ?
- A. 45
  - B. 90
  - C. 270
  - D. 810

**DO YOUR FIGURING HERE.**

that is,  $68t + 57t = 240$ . The solution for  $t$  in this equation is 1.92, which is approximately 1 hour plus an additional 0.92 hours times StartFraction 60 min Over 1 hr EndFraction equals 55.2 minutes. Thus, they pass each other approximately 1 hour 55 minutes after 2:00 p.m., or 3:55 p.m. If you chose **A**, you may have used 68 mph for both drivers, solving  $68t + 68t = 240$ . If you chose **B**, you may have divided  $\frac{240}{68} \approx 3.529$  and incorrectly thought that this was 3:53 p.m. If you chose **D**, you may have used 57 mph for both drivers, solving  $57t + 57t = 240$ .

**Question 42. The correct answer is H.** Selecting every possible pair of points from among 10 points is, by definition, calculating the combination of 10 objects taken 2 at a time:

$$\binom{10}{2} = \frac{10!}{(10-2)!2!} = \frac{10 \cdot 9 \cdot 8!}{8!2!} = \frac{10 \cdot 9}{2} = 45.$$
 If you chose **F**, you may have thought 10 points would determine 10 lines. If you chose **G**, you may have thought 10 points taken 2 at a time would determine  $10 \cdot 2 = 20$  lines. If you chose **J**, you may have counted each line twice by counting 10 choices for the first point and 9 choices for the second point. Since switching the order of 2 points will still determine the same line, each possibility is counted twice here.

**Question 43. The correct answer is A.** Using the given definition, manipulate the fraction to obtain an equivalent expression:

$$\frac{(n+1)!6!}{n!3!} = \frac{(n+1)n!6 \cdot 5 \cdot 4 \cdot 3!}{n!3!} = (n+1)6 \cdot 5 \cdot 4 = 120(n+1)$$

. If you chose **B**, you may have calculated  $\frac{6!}{3!}$ , ignoring  $n$ . If you chose **C**, you may have ignored the factorials and simplified. If you chose **D**, you may have incorrectly thought that multiplication and factorials can be interchanged:  $n!m! = (nm)!$ .

**Question 44. The correct answer is J.** The expanded form of  $(x + 1)^4$  is

$$(x + 1)^2(x + 1)^2 = (x^2 + 2x + 1)(x^2 + 2x + 1) = x^4 + 4x^3 + 6x^2 + 4x + 1$$

. The coefficient of  $x^2$  is 6. If you chose **F**, you may have thought the expansion of  $(x + 1)^4$  was  $x^4 + 1$ , so there was no  $x$  squared term. If you chose **G**, you may have thought the expansion of  $(x + 1)^4$  was  $x^4 + 4x^3 + 6x^2 + 4x + 1$ , so the coefficient of  $x^2$  was 6.

If you chose **H**, you may have thought the expansion of

$(x + 1)^4$  was  $x^4 + 2x^3 + 4x^2 + 2x + 1$ , so the coefficient of  $x^2$  was 4.

**Question 45. The correct answer is D.** In the diagram,  $\triangle ADC$  is a right triangle, so

$m\angle A + m\angle C = 90^\circ$ . Since  $m\angle C = 20^\circ$ ,  $m\angle A = 70^\circ$ .

By the property of supplementary angles,  $m\angle ACB = 180^\circ - 70^\circ = 110^\circ$ . In

$\triangle ABC$ , two sides and the included angle are known, so the measure of the remaining side can be calculated using the law of cosines. Let  $g$  = the length of the guy wire. Then

$g^2 = 60^2 + 25^2 - 2(60)(25)\cos 110^\circ$   
 Taking the square root of both sides gives the desired result. If you chose **A**, you may have incorrectly assumed  $m\angle BAC = 20^\circ$  and

$m\angle ACB = 60^\circ$ , then calculated the length of the guy wire using the

law of sines:  $\frac{\sin 60^\circ}{g} = \frac{\sin 20^\circ}{25}$ . If you chose **B**, you

may have incorrectly assumed  $m\angle BAC = 20^\circ$  and  $m\angle ACB = 70^\circ$ , then calculated the length of the guy wire using the law of sines:

$\frac{\sin 70^\circ}{g} = \frac{\sin 20^\circ}{25}$

. If you chose **C**, you may have thought that  $m\angle ACB = 90^\circ - 20^\circ = 70^\circ$ , then correctly used the law of cosines:  $g^2 = 60^2 + 25^2 - 2(60)(25)\cos 70^\circ$ .

## **NOTES**