

The **ACT** Course Book

MATHEMATICS & SCIENCE

Focusing on the Individual Student



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CONTENTS

TEST-TAKING FUNDAMENTALS

About the ACT	2
Your Commitment	3
ACT Structure	4
Content	5
Scoring	6
Knowing Your Limits	8

MATH OVERVIEW

The Mathematics Test	12
Format	14
Question Difficulty	15
Working Through the Math Test	16
Attractors	17
Setting Your Goal	18
Problem-Solving Tools	20
Plugging In	22
Choosing Numbers	24
Guesstimating	26
Bridging the Gap	28
Using Your Calculator	30

INTEGRATING ESSENTIAL SKILLS

Multiples, Factors, & Divisibility	36
Fractions	38
Ratios	40
Proportions	42
Digits & Place Value	44
Percents	46
Charts & Graphs	50

Number & Quantity Foundations	56
Algebra Foundations	60
Geometry Foundations – xy -Plane	64
Geometry Foundations – Angles	68
Geometry Foundations – Triangles	72
Geometry Foundations – Area & Volume	76
Statistics & Probability Foundations	80
Integrating Essential Skills Practice	87

NUMBER & QUANTITY

Number Properties	106
Imaginary & Complex Numbers	108
Translation	112
Matrices	116
Vectors	118
Number & Quantity Practice	123

ALGEBRA

Exponents	130
Roots	132
Algebraic Expressions	134
Equations	136
Graphs of Linear Equations	138
Inequalities	140
Graphs of Inequalities	142
Systems of Equations	144
Quadratic Equations & Expressions	148
Polynomials	150
Algebra Practice	157

GEOMETRY

Vocabulary	170
Similar & Congruent Triangles	172
Right Triangles	174
SOH CAH TOA	176
Midpoint & Distance	178
Transformations	180
Conic Sections	182
Geometry Practice	189

FUNCTIONS

Functions	200
Graphs of Functions	204
Trigonometry Identities	208
Laws of Sines & Cosines	212
The Unit Circle	214
Graphs of Sine & Cosine	218
Sequences	220
Logarithms	222
Functions Practice	227

STATISTICS & PROBABILITY

Averages	240
Combinations & Permutations	242
Probability	244
Statistics & Probability Practice	249

SCIENCE OVERVIEW

The Science Test	254
Format and Scoring	255
Attractors	256
Setting Your Goal	258
Working Through the Science Test	260
General Tips	261

SCIENCE

The Scientific Method	264
Data Representation Overview	266
Interpretation	268
Relationship	272
Additional Data	276
Connection	280
Research Summary Overview	284
Data	286
Experimental Design	288
Evaluation	292
Conflicting Viewpoints Overview	298
Detail	300
Perspective	302
Assessment	306

Science Appendix	315
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Science Practice	319
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ANSWER KEY

365

Preface

Since 1988, when two Yale University graduates started Summit Educational Group, tens of thousands of students have benefited from Summit's innovative, comprehensive, and highly effective test preparation. You will, too.

Successful test-takers not only possess the necessary academic skills but also understand how to take the ACT. Through your ACT program, you'll learn both. You'll review and develop the academic skills you need, and you'll learn practical, powerful, and up-to-date test-taking strategies.

The *Summit ACT Course Book* provides the skills, strategies, and practice necessary for success on the ACT. The result of much research and revision, this book is the most effective, innovative, and comprehensive preparation tool available.

This book's first chapter – Test-Taking Fundamentals – gives students a solid foundation of ACT information and general test-taking strategies. The following chapters cover the Math and Science content strands of the ACT. Each chapter is divided into manageable topic modules. Modules consist of the skills, strategies, and common question types for particular topics, *Try It Out* questions, and *Put It Together* questions. At the end of each chapter, homework questions provide additional practice.

Some Math modules include frequencies and difficulty ranges for specific question types. These are not absolute, but are general trends based on research of many official ACTs. Difficulty is labeled as "E" (Easy), "M" (Medium), and "H" (Hard). These ratings roughly translate to questions 1-25, 20-45, and 40-60, respectively, in an ACT Math Test.

We are confident that you will not find a more complete or effective ACT program anywhere.

We value your feedback and are always striving to improve our materials. Please write to us with comments, questions, or suggestions for future editions at:

edits@mytutor.com

Your program will give you the skills, knowledge, and confidence you need to score your best.

Good luck, and have fun!

Integrating Essential Skills Summary

Multiples, Factors, and Divisibility

- A multiple of an integer is any integer that is divisible by that integer.
- A number is a factor of an integer if it divides evenly into that integer.
- A number is divisible by another number if it can be divided evenly by that number.
- A remainder is the integer left over when you divide two numbers.

Fractions

- To add or subtract fractions, first adjust the fractions so they have a common denominator. Then add or subtract the numerators only.
- To multiply fractions, multiply straight across (numerator by numerator and denominator by denominator).
- To divide fractions, multiply by the reciprocal of the divisor (the number you're dividing by).

Ratios

- Know how to find the ratio between a part and a whole when given a ratio between parts.

Proportions

- Solve proportions by cross-multiplying. If $\frac{a}{b} = \frac{c}{d}$, then $a \times d = b \times c$.

Digits and Place Value

- The position of each digit in a number determines the digit's place value.
- In "scientific notation," a number is written so that the largest digit is in the units place, and it is multiplied by a power of 10.

Percents

- Percents, decimals, and fractions can all be used interchangeably.
- Find what percent one number is of another by dividing the part by the whole and then converting the resulting decimal to a percent.

Charts & Graphs

- Graphs describe the relationship between two sets of data, such as weight versus height or distance versus time. Questions will ask you to make calculations, interpret trends, identify correlations, and make predictions.
- Different types of charts and graphs are used to display information. Pay attention to the labels and units.

Foundations

- Questions that involve basic skills in other content areas are categorized as Integrating Essentials Skills questions. Simple equation or angle questions are common Integrating Essential Skills questions.

Number & Quantity Summary

Number Properties

- To simplify an expression within an absolute value sign, simplify just as you would simplify an expression in parentheses. Then take the absolute value of the result.
- A rational number can be expressed as the fraction $\frac{p}{q}$, where both p and q are integers and denominator q is not zero.
- An irrational number cannot be expressed as a fraction or a ratio of integers.

Imaginary & Complex Numbers

- An imaginary number has a square that is a negative number. A complex number is the sum of a real and an imaginary number.
- Divide complex numbers by multiplying the numerator and the denominator by the complex conjugate of the denominator
- In a complex plane, the vertical axis is the imaginary axis and the horizontal axis is the real axis.

Translation

- Translate math problems word-by-word to create equations.
- For word problems that ask for an expression to represent a situation, check your answer by Choosing Numbers for variables.
- Follow these broad steps to solve ACT word problems:
 1. What's needed? Determine what calculation is necessary in order to solve the problem.
 2. What's first? Consider what you can do with the information provided. Break down the problem into manageable steps.
 3. Translate, if necessary. Pick variables to represent unknown values, and translate the word problem into algebraic expressions and equations.
 4. Solve for one value at a time until you find your final answer.
 5. Check your answer! Is it what the question asked for? Does it make sense with the given information?

Matrices

- ❑ To add or subtract matrices, simply perform the operation on the corresponding terms.
- ❑ To multiply two matrices, multiply each row in the first matrix by each column in the second matrix.
- ❑ For a 2×2 matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$, the determinant is equal to $ad - bc$.

Vectors

- ❑ Component form of a vector \mathbf{v} is $\langle a, b \rangle$, where a represents the x -component and b represents the y -component of the vector on the (x, y) coordinate plane. This can also be expressed in unit vector notation as $a\mathbf{i} + b\mathbf{j}$. This can be graphed as a line segment with a terminal point that is a units left and b units up from the initial point.
- ❑ The magnitude of a vector can be found by plotting the vector on the (x, y) coordinate plane and calculating the length with the distance formula. If no endpoints are given, calculate the magnitude as the distance from the origin.
- ❑ If two vectors are added together, the resultant is found by placing the vectors to be added end to end. If the vectors are given in component vector form, you simply add together the corresponding units.

Algebra Summary

Exponents

- An exponent shows the number of times that a value is multiplied by itself.
- To solve an equation with a variable as an exponent, first make sure that each exponent has the same base. Then set the exponents equal to each other and solve.

Roots

- The root of a number is a value that, when multiplied by itself a certain number of times, gives the number. Think of roots as the inverse of exponents.
- A root can be expressed using a radical sign or a fractional exponent

Algebraic Expressions

- Simplify an expression by combining like terms.
- Use the distributive property to multiply a single term by an expression inside parentheses.
- When multiplying two binomials, each term must be multiplied by each term in the other binomial.
- Factoring is expanding in reverse. Find common factors among the terms in an expression and rewrite using a multiplication.

Equations

- To solve for a variable, isolate the variable on one side of the equal sign.

Inequalities

- Inequalities can be solved like equations, with one important difference: if you multiply or divide both sides by a negative number, you must switch the direction of the inequality sign.
- To graph an inequality, first rewrite as an equation and graph the resulting line. The graph of the inequality will be the area above or below this line. If the solution to the inequality does not include the points on the line, use a dashed line.

Systems of Equations

- ❑ A system of linear equations, also called simultaneous equations, is a set of two or more equations working together. Simultaneous equations can be solved graphically and algebraically.
- ❑ When lines are parallel, there is no common solution. When lines overlap, there are infinitely many solutions.
- ❑ Word problems that require you to define two variables are often simultaneous equation questions. Learn to recognize them and translate to set up the equations.

Quadratic Equations

- ❑ If you can factor it, factor it! Most quadratics questions require factoring as one of the steps in the solution. Before factoring a quadratic equation, make sure that the equation is set equal to zero.
- ❑ If a quadratic equation cannot be easily factored, use the quadratic formula.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \text{ where } a, b, \text{ and } c \text{ are coefficients in the equation } ax^2 + bx + c = 0.$$

Polynomials

- ❑ A solution to a polynomial equation is also a root of the equation, a zero of the function, and an x -intercept. Any of these can be used to find a factor of the polynomial.
- ❑ Find the solutions of a polynomial by setting the polynomial equal to zero and factoring. Once in factored form, set each factor equal to zero to find the solutions.

Geometry Summary

Similar & Congruent Triangles

- ❑ Similar triangles have corresponding angles that are equal and corresponding sides that are proportional. Similar triangles have the same shape but not necessarily the same size.
- ❑ Congruent triangles are equal in size and shape. Corresponding sides and angles are equal.

Right Triangles

- ❑ A 45-45-90 triangle is an isosceles right triangle whose sides are in the ratio of $1:1:\sqrt{2}$.
- ❑ A 30-60-90 triangle is a right triangle whose sides are in the ratio of $1:\sqrt{3}:2$.
A 30-60-90 right triangle is half of an equilateral triangle.

SOH CAH TOA

- ❑ SOH CAH TOA is an acronym that represents the right triangle relationships for sine, cosine, and tangent.

$$\text{SOH: } \sin \theta = \frac{\text{length of Opposite side}}{\text{length of Hypotenuse}}$$

$$\text{CAH: } \cos \theta = \frac{\text{length of Adjacent side}}{\text{length of Hypotenuse}}$$

$$\text{TOA: } \tan \theta = \frac{\text{length of Opposite side}}{\text{length of Adjacent side}}$$

Midpoint & Distance

- ❑ The midpoint of a segment is given by: $\text{midpoint} = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2} \right)$

- ❑ The distance between two points is given by: $\text{distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

Transformations

- ❑ Translation is the process of moving a point or figure a specified distance in a certain direction.
- ❑ Reflection is the process of moving a point or figure by mirroring it over a line.
- ❑ Rotation is the process of moving a point or figure by rotating it around a point.
- ❑ Shapes have symmetry when they can be transformed to be exactly like one another. An axis of symmetry is a line that divides a figure into symmetrical images.

Conic Sections

□ Equation of a circle: $(x - a)^2 + (y - b)^2 = r^2$

In this form, (a, b) is the center and r is the radius. A circle centered at the origin has the equation $x^2 + y^2 = r^2$.

- Complete the Square – If a circle equation is not in standard form, put it in standard form by “completing the square.” For an expression $x^2 + bx$, rewrite as $\left(x + \frac{b}{2}\right)^2$, then FOIL and rebalance the equation.

□ Equation of a parabola: $y = ax^2 + bx + c$

The x -intercepts of the parabola are the zeroes or solutions to the quadratic when $y = 0$. The parabola’s axis of symmetry is the x value of the midpoint of these x -intercepts.

In this form, $x = -\frac{b}{2a}$ is the axis of symmetry. A parabola centered at the origin has the equation $y = ax^2$.

□ Equation of an ellipse: $\frac{(x - h)^2}{a^2} + \frac{(y - k)^2}{b^2} = 1$

In this form, (h, k) is the center. $2a =$ length of the horizontal axis of the ellipse. $2b =$ length of the vertical axis of the ellipse.

An ellipse centered at the origin has the equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

□ Equation of a hyperbola: $\frac{(x - h)^2}{a^2} - \frac{(y - k)^2}{b^2} = 1$

In this form, (h, k) is the center. Every hyperbola has two asymptotes given by the equation $y = \pm \frac{b}{a}(x - h) + k$.

Functions Summary

Functions

- ❑ To evaluate a function for a particular value of x , simply substitute that value everywhere you see an x .
- ❑ The domain of a function is the complete set of possible x values. The range of a function is the set of possible y values, or the resulting values of $f(x)$ for the full set of x values.

Graphs of Functions

- ❑ On the xy -coordinate plane, $f(x)$ is the y -coordinate of function f for a value x .
- ❑ Memorize the following graph transformation rules:

$f(x) + n$ shifts the graph UP by n units.

$f(x) - n$ shifts the graph DOWN by n units.

$f(x + n)$ shifts the graph to the LEFT by n units.

$f(x - n)$ shifts the graph to the RIGHT by n units.

$-f(x)$ reflects the graph over the x -axis.

$f(-x)$ reflects the graph over the y -axis.

Trigonometry Identities

❑ Tangent: $\tan \theta = \frac{\sin \theta}{\cos \theta}$

❑ Secant: $\sec \theta = \frac{1}{\cos \theta}$

❑ Cotangent: $\cot \theta = \frac{\cos \theta}{\sin \theta} = \frac{1}{\tan \theta}$

❑ Cosecant: $\csc \theta = \frac{1}{\sin \theta}$

- ❑ When the ratio of a triangle's side lengths is known, inverse functions can be used to find the measure of an angle.

$$y = \arcsin(x) = \sin^{-1}(x) \longrightarrow x = \sin(y)$$

$$y = \arccos(x) = \cos^{-1}(x) \longrightarrow x = \cos(y)$$

$$y = \arctan(x) = \tan^{-1}(x) \longrightarrow x = \tan(y)$$

- ❑ Addition formulas:

$$\sin(a + b) = (\sin a \times \cos b) + (\sin b \times \cos a)$$

$$\cos(a + b) = (\cos a \times \cos b) - (\sin a \times \sin b)$$

$$\tan(a + b) = \frac{\tan a + \tan b}{1 - (\tan a \times \tan b)}$$

- ❑ Double-angle formulas:

$$\sin(2a) = 2(\sin a \times \cos a)$$

$$\cos(2a) = \cos^2 a - \sin^2 a$$

$$\tan(2a) = \frac{2 \tan a}{1 - \tan^2 a}$$

- ❑ $\sin^2 \theta + \cos^2 \theta = 1$

Laws of Sines & Cosines

- ❑ Law of Sines: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

- ❑ Law of Cosines: $c^2 = a^2 + b^2 - 2ab \cos C$

Unit Circle

- ❑ Angles can be measured in both degrees and radians. 180 degrees is equal to π radians.

To convert from radians to degrees, multiply by $\frac{180}{\pi}$.

To convert from degrees to radians multiply by $\frac{\pi}{180}$.

Graphs of Sine & Cosine

- ❑ The amplitude shows how "tall" the graph is. For $y = A \sin Bx$, A is the amplitude.

- ❑ The period is how long it takes for the graph to go through one complete cycle.

For $y = A \sin Bx$, $\frac{2\pi}{B}$ is the period.

Sequences

- ❑ An arithmetic sequence is a list of numbers in which the difference between consecutive numbers is constant: $a_n = a_1 + (n - 1)d$

- ❑ A geometric sequence is a list of numbers in which there is a common ratio between consecutive numbers: $a_n = a_1 \times r^{n-1}$

Logarithms

- ❑ Memorize the following logarithm rules:

$$\log_b x + \log_b y = \log_b (xy)$$

$$\log_b x - \log_b y = \log_b \left(\frac{x}{y} \right)$$

$$y \log_b x = \log_b (x^y)$$

Statistics & Probability Summary

Averages

- ❑ Average = $\frac{\text{sum of parts}}{\text{number of parts}}$
- ❑ (average) \times (number of parts) = sum of parts
- ❑ To find the average of two averages, you must first find the two subtotals, add them, and then divide by the combined number of parts.
- ❑ To find the weighted average of the set, multiply each element by its respective weight, add the resulting values. You can solve a probability distribution in the same way to find an expected value.

Combinations & Permutations

- ❑ Fundamental Principle of Counting – The number of possible outcomes can be found by multiplying the number of ways each event can occur.
- ❑ In combinations, the order of events does not change the outcome. For most combinations questions, choices cannot be repeated, so there will be a decreasing number of options available. Factorials are used to represent the product of a decreasing set of consecutive integers. For example, $5! = 5 \times 4 \times 3 \times 2 \times 1$. Use the following notations when choosing r items from a set of n items:

$$C(n, r) \text{ or } {}_n C_r \text{ or } \frac{n!}{r!(n-r)!}$$

- ❑ Permutations – In permutations, the order of events matters. Use the following notations when choosing r items from a set of n items:

$$P(n, r) \text{ or } {}_n P_r \text{ or } \frac{n!}{(n-r)!}$$

Probability

□ Probability of an event happening = $\frac{\# \text{ of ways the event can happen}}{\# \text{ of possible outcomes}}$

□ To find the probability of one event *or* another event occurring, *add* the probabilities of each event. If there is any overlap between the two events, subtract this overlap from the sum.

To find the probability of one event *and* another event occurring, *multiply* the probabilities of each event. If the events are dependent, the results of the first event will affect the later events. Some difficult probability questions require combinations skills to calculate numbers of outcomes.



Integrating Essential Skills

□ Multiples, Factors, & Divisibility	36
□ Fractions	38
□ Ratios	40
□ Proportions	42
□ Digits & Place Value	44
□ Percents	46
□ Charts & Graphs	50
□ Number & Quantity Foundations	56
□ Algebra Foundations	60
□ Geometry Foundations	
○ xy -Plane	64
○ Angles	68
○ Triangles	72
○ Area & Volume	76
□ Statistics & Probability Foundations	80

PUT IT TOGETHER

1. Which of the following numbers is greatest in value?
 - A. 2.8×10^{-9}
 - B. 280×10^4
 - C. 0.28×10^9
 - D. 280,000
 - E. 0.0028×10^7

2. What percentage of the integers from 1 to 50, inclusive, have a units digit that is three times the tens digit?
 - F. 3
 - G. 6
 - H. 12
 - J. 16
 - K. 24

3. If there are 6×10^7 oxygen molecules in a volume of 3×10^2 cubic centimeters, what is the average number of oxygen molecules per cubic centimeter?
 - A. 5×10^{-6}
 - B. 2×10^5
 - C. 2×10^9
 - D. 18×10^9
 - E. 18×10^{14}

4. Which of the following numbers is greatest in value?
 - F. 0.2
 - G. $0.\overline{2}$
 - H. 0.222
 - J. 0.223
 - K. 0.2222

Percents

1-2 per test E M H

A percent is a ratio that compares a number to 100.

Most percent questions on the ACT are word problems involving changes to a certain value. Some questions can be simplified by converting percents to familiar fractions or decimals.

- ❑ Percents, decimals, and fractions can all be used interchangeably. Memorize common percent-fraction-decimal equivalents.

Complete the table below.

Fraction			$\frac{1}{3}$	$\frac{1}{2}$	
Percent	10%				80%
Decimal		0.20			

- ❑ Find what percent one number is of another by dividing the part by the whole and then converting the resulting decimal to a percent.

Remember the “is over of” rule. The number next to the “is” should go in the numerator (the part). The number next to the “of” should go in the denominator (the whole).

9 is what percent of 12?

What is $\frac{1}{2}$ % of $\frac{1}{2}$?

- ❑ **Percent Increase or Decrease** – To find the percent increase or decrease from one number to another, divide the difference between the numbers by the original number, then convert the resulting decimal to a percent.

$$\% \text{ increase/decrease} = \frac{\text{change}}{\text{original \#}}$$

The price of a printer is marked down from \$200 to \$150. What is the percent markdown in price?



Integrating Essential Skills Practice

Multiples, Factors, and Divisibility

Questions 1-2: E

1. Which of the following is an odd, positive integer?

A. $11(-7)$

B. 4^3

C. $\frac{-6 \times 5}{-2}$

D. $\frac{36}{9}$

E. $38 - 14$

2. What is the sum of the prime factors of 105?

F. 8

G. 10

H. 15

J. 22

K. 29

Fractions

Questions 3-4: E

Questions 5-6: M

3. Which of the following lies between 3 and 4?

A. $\frac{8}{2} \times \frac{5}{3}$

B. $\frac{8}{3} \times \frac{5}{2}$

C. $\frac{8}{3} \times \frac{7}{5}$

D. $\frac{8}{5} \times \frac{3}{2}$

E. $\frac{8}{7} \times \frac{5}{3}$

4. What is the correct ordering of $\sqrt{2}$, $\frac{9}{7}$, and $\frac{3}{2}$ from least to greatest?

F. $\frac{3}{2} < \frac{9}{7} < \sqrt{2}$

G. $\frac{3}{2} < \sqrt{2} < \frac{9}{7}$

H. $\frac{9}{7} < \sqrt{2} < \frac{3}{2}$

J. $\sqrt{2} < \frac{3}{2} < \frac{9}{7}$

K. $\sqrt{2} < \frac{9}{7} < \frac{3}{2}$

5. For what value(s) of x is the expression

$$\frac{1}{(x-2)(x-3)}$$
 undefined?

A. 2

B. -3

C. -2, -3

D. 2, -3

E. 2, 3

6. $\frac{2a}{4} + \frac{3a}{7} + \frac{4a}{14} = ?$

F. $\frac{9a}{28}$

G. $\frac{17a}{14}$

H. $\frac{17a}{7}$

J. $\frac{29a}{28}$

K. $\frac{17a}{9}$

Ratios

Question 7: E
 Question 8: M

7. Three friends found \$45 in the street and decide to split it in the ratio of 5:3:1. What is the amount of the largest share?
- A. \$1
 - B. \$3
 - C. \$5
 - D. \$15
 - E. \$25
8. If the ratio of x to y is 5:6, and the ratio of y to z is 1:2, what is the ratio of x to z ?
- F. 1:3
 - G. 5:12
 - H. 3:5
 - J. 5:3
 - K. 5:2

Proportions

Question 9: E
 Question 10: M

9. Cory presented a scale drawing of the tree house he was working on to his class. In the drawing, the tree house is 15 inches wide and 12 inches tall. Cory told the class that he planned for the tree house to be 8 feet tall. Given this information, how wide did he plan for the tree house to be?
- A. 6 feet
 - B. 7.5 feet
 - C. 9 feet
 - D. 10 feet
 - E. 12 feet

10. Jen and her friends decide to sell lemonade on their street corner. They use 5 scoops of lemonade mix to make 3 pitchers of lemonade. Later, Jen decides that she and her friends will be able to sell eleven more pitchers of lemonade before it is time for supper. How many scoops of lemonade mix will be needed to make the additional eleven pitchers?
- F. 5
 - G. $6\frac{2}{3}$
 - H. 7
 - J. $11\frac{1}{3}$
 - K. $18\frac{1}{3}$

Percents

Questions 11-13: E
 Question 14: M

11. If 60% of $x = 90$, then $x = ?$
- A. 54
 - B. 108
 - C. 126
 - D. 150
 - E. 540
12. Sally bought two shirts at a local department store for a total of \$19.99, not including taxes. If there is an 8% sales tax on the shirts, to the nearest cent, how much tax did Sally have to pay on her shirts?
- F. \$1.45
 - G. \$1.52
 - H. \$1.60
 - J. \$1.76
 - K. \$1.95



Science Overview

- ❑ The Science Test
- ❑ Format and Scoring
- ❑ Attractors
- ❑ Setting Your Goal
- ❑ Working Through the Science Test
- ❑ General Tips

The Science Test

Format	40 questions Multiple-choice 4 answer choices
Content	Biology Chemistry Physics Geology Astronomy Meteorology
Scoring	Science Test Score: 1-36 Subscores (reported as percent of possible): Interpretation of Data Scientific Investigation Evaluation of Models, Inferences, & Experimental Results
Time	35 minutes

- The Science Test does not focus on your knowledge of scientific facts. Instead, it tests how well you can use the skills of scientific reasoning.
- Almost all of the questions in the Science Test can be answered by referring only to the material presented in the relevant passages. However, between 1 and 5 questions per test may rely upon scientific knowledge not contained in their passages.

A few questions may require mathematic calculations. In addition to identifying trends or finding averages, you may occasionally have to use algebra or geometry skills.

- Each Reading Test contains a specific number of questions in certain categories:

Category	Questions	Question Types
Interpretation of Data	18-22	Interpretation, relationship, connection, detail
Scientific Investigation	8-12	Experimental design, additional data
Evaluation of Models, Inferences, & Experimental Results	10-14	Evaluation, perspective, assessment

Format and Scoring

- ❑ You receive 1 raw point for a correct answer. You lose nothing for incorrect answers. Your **raw score** is calculated by adding up raw points. Your raw score is then converted to a **scaled score** from 1-36.

- ❑ You are asked to work through 6 or 7 passages. Each test contains:
 - 12-16 Data Representation questions. Each passage typically has 5 questions.
 - 18-22 Research Summary questions. Each passage typically has 6 questions.
 - 6-8 Conflicting Viewpoints questions. Each passage typically has 7 questions.

- ❑ **Data Representation** passages describe scientific phenomena. They typically present graphs and tables which quantify the relationships between 2-4 different variables. Data Representation questions will ask you to describe the relationships between the variables.

- ❑ **Research Summary** passages describe scientific experiments and their results. They typically detail the experiment's hypothesis, design, and quantifiable results. Research Summary questions will ask you about the experiment's design, execution, and conclusions.

- ❑ **Conflicting Viewpoints** passages present two or more theories about various scientific phenomena. Not all theories can be correct. These questions will not necessarily ask you to determine which theory is correct, but they will ask you to describe each viewpoint and its relationships to the others.

- ❑ The instructions are the same on every ACT. Familiarize yourself with the instructions before you take the test. At test time, you can skip the instructions and focus on the problems.

DIRECTIONS: There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

You are NOT permitted to use a calculator on this test.