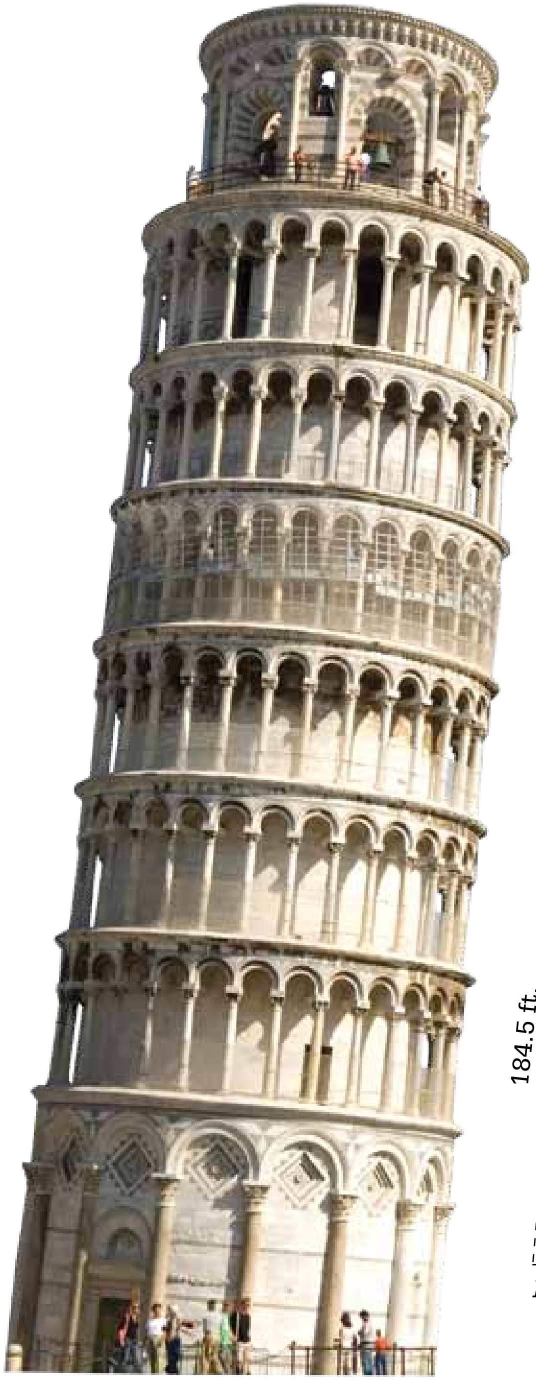
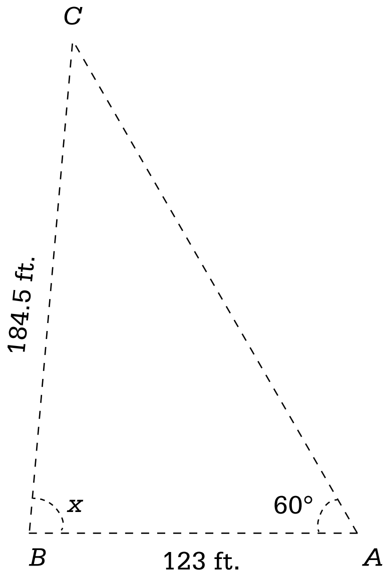
SAT **Subject Tests**™

Mathematics | History | Science | Literature | Languages

TEACHER'S GUIDE to SAT Subject Tests™





Mathematics

Level 1 • Level 2

achieve more

SAT

Dear Educator,

We know connecting your students with college opportunity and success is important to you. One way to help your students along the path to higher education is to share with them the benefits of taking SAT Subject Tests™.

The SAT Subject Tests are hour-long tests based on high school course work offered across five subject areas: Mathematics, Science, English, History and Languages.

Coupled with students' high school grades and SAT® scores, Subject Test scores can create a powerful and comprehensive picture of your students' capabilities, helping them stand out to prospective colleges. Colleges also use SAT Subject Tests to put other admission factors into context, place students in certain courses, and even offer credit based on Subject Test performance.

To better support you in helping your students do well on these tests, we are pleased to provide you with the *Teacher's Guide to SAT Subject Tests in Mathematics*, a comprehensive resource that will familiarize you with the mathematics tests and the topics they cover. It also includes sample questions as well as tips and best practices from other teachers to help you prepare your students to do their best on the SAT Subject Tests.

The best news for math teachers? SAT Subject Tests cover the material you already teach your students and strongly align with the Common Core State Standards. In fact, nearly 90 percent of the items on the Math I and Math II Subject Tests aligned with one or more of the Common Core standards in Math. Eighty percent of high school math teachers agree that the knowledge and skills measured by the SAT Subject Tests in Mathematics are part of their existing curriculum. Almost 90 percent of mathematics and English high school teachers and college professors indicated that the knowledge and skills tested on the SAT Subject Tests are important for college readiness.

There is no better source than you — teachers in the classroom — when it comes to helping students prepare for the SAT Subject Tests. If you have feedback, tips or ideas you'd like to share with other teachers, please send them to us at SATSubjectTests@collegeboard.org so we can include them in future guides.

The SAT Subject Tests in Mathematics help your students shine in the college admission process. We appreciate the opportunity to partner with you to help your students showcase the knowledge and skills you have taught them.

The College Board

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What Are the SAT Subject Tests™?

SAT Subject Tests™ are one-hour-long exams that give students the opportunity to enhance their college admission credentials by demonstrating their knowledge of specific subjects.

They are the only national admission tests where your students choose to take the tests that best showcase their achievements and interests.

Because every student is unique, a student's academic record often doesn't tell the whole story of a student's capabilities and potential. Encourage your students to consider taking one or more SAT Subject Tests so they can show colleges a more complete picture of their academic background, interests and talents.

What Are the Benefits of Taking the SAT Subject Tests in Mathematics?

The SAT Subject Tests in Mathematics can help students differentiate themselves in a competitive college admission environment by providing additional information about their readiness for college-level study. This is important for all students as it contextualizes other academic credentials, such as grades, SAT scores, etc.

Some schools require an SAT Subject Test in Science for admission into science and engineering programs or majors, while others require the tests from all students. For example, the California Institute of Technology requires all applicants to submit Subject Test scores in both mathematics and science. Many colleges use Subject Tests to advise students or help with course placement. Other schools allow students to place out of introductory courses or gain credit based on their performance on certain Subject Tests. Students can visit bigfuture.collegeboard.org/college-search to explore colleges and get information about Subject Test requirements.

Tip

Students can use SAT Subject Tests for purposes beyond college admission and placement. For example, students in New York can use them as a substitute for some Regents exams for a New York State Regents high school diploma. Subject Tests can also be used to fulfill subject-based competency requirements for large university systems like the University of California and the University of Arizona.

What Are the Differences Between the SAT® and the SAT Subject Tests?

The SAT is the most widely used college entrance exam, testing what students learn in classrooms and how well they apply that knowledge. Its reading, math and writing sections are based on the critical thinking and problem solving skills needed for college success.

SAT Subject Tests cover a wide range of subject areas, including science, history and languages. Each SAT Subject Test focuses on a single subject and indicates a student's readiness to take college-level courses in that subject.

Tip

Encourage your math students who are applying to competitive colleges or programs of study to take an SAT Subject Test in Mathematics to enhance their college applications.

Which Students Should Take SAT Subject Tests?

Many students can benefit from taking SAT Subject Tests to highlight their knowledge of a specific subject or subjects. SAT Subject Tests may be especially beneficial for students who:

- Are applying to colleges that require or recommend Subject Tests for admission and/or specific majors or areas of study.
- Want to show strength in specific subject areas.
- Would like to demonstrate knowledge obtained outside a traditional classroom environment (e.g., summer enrichment, distance learning, weekend study, etc.).
- May be able to place out of certain classes in college.
- Are enrolled in dual-enrollment programs.
- Are home-schooled or taking courses online.

Tip

Encourage your math students who may not be as strong in other academic areas or who are English language learners (ELL) to take the SAT Subject Tests in Mathematics to showcase their science knowledge. ELL students may benefit from taking an SAT Subject Test in Mathematics because it is not as reliant on English language mastery.

Should Students Taking Advanced Placement® Classes Take SAT Subject Tests?

SAT Subject Tests are high school level tests, reflecting high school curricula. AP® Exams assess a student's college-level knowledge, skills and abilities learned in the corresponding AP courses in high school. Many colleges still require students to submit SAT Subject Test scores, even if they've taken AP Exams. Students taking AP courses may benefit from taking SAT Subject Tests as an additional opportunity to show colleges their knowledge of specific subjects. They also can gauge student readiness for AP Exams. As a result, some students take SAT Subject Tests as early as the spring of their freshman or sophomore years.

When Should Students Take SAT Subject Tests?

The best time for students to take the SAT Subject Tests is after they complete the corresponding course or set of courses, when the content is still fresh in their minds. Students who wait until the fall of their senior year to take tests may miss the opportunity to put their best foot forward.

Not every test is offered on every test date, so encourage your students to review the SAT Subject Test calendar early so they can plan accordingly. The test calendar can be found on sat.collegeboard.org/register/sat-subject-test-dates.

Tip

Suggest that your students take the SAT Subject Tests in Mathematics after they have two or more years of course work.

How Do Colleges Use SAT Subject Test Scores?

Colleges use SAT Subject Test scores to gain a more comprehensive understanding of a student's academic background and achievement in specific areas. They use this information, along with factors like high school grades, extracurricular activities and other test scores, to make admission or placement decisions.

Some colleges require Subject Test scores for general admission or acceptance into certain majors or courses of study.

Other schools recommend Subject Test scores to help them make more informed admission decisions, and nearly all schools will take Subject Test scores into consideration as part of a student's college application.

Many colleges also use Subject Tests for course placement and advising, and others will allow students to place out of introductory courses or receive credits based on performance on certain Subject Tests.

Most college websites and catalogs include information about admission requirements, including which Subject Tests are needed or recommended for admission. Advise your students to research Subject Test requirements and recommendations for schools they are interested in attending.

Tip

Students who are interested in majoring in subjects with a quantitative focus, such as economics and STEM (Science, Technology, Engineering and Math), usually benefit from taking the SAT Subject Tests in Mathematics.

"At Caltech, where the academic emphasis is on STEM fields, it is critical for us to require and evaluate certain SAT Subject Tests in math and science to get a stronger sense of a student's true passion and strength in these areas. We select candidates from a talented pool of applicants, and SAT Subject Tests help us to better understand a student's preparation for our demanding curriculum."

—Jarrid Whitney, Executive Director of Admissions and Financial Aid
California Institute of Technology

What Subject Tests Are Offered?

Twenty tests are offered in five subject areas: Science, Mathematics, English, History and Languages. Three of the tests are in Science: Biology E (Ecological focus) or M (Molecular focus), Chemistry and Physics.

English	Literature
History	United States History
	World History
Mathematics	Mathematics Level 1
	Mathematics Level 2
Science	Biology E/M
	Chemistry
	Physics

Languages	
Reading Only	**Languages with Listening**
French	Chinese
German	French
Italian	German
Latin	Japanese
Modern Hebrew	Korean
Spanish	Spanish

Which Subject Tests Should Your Students Take?

When you advise your math students to take SAT Subject Tests in mathematics, consider encouraging them to take other SAT Subject Tests in areas in which they excel or have an interest. In addition, students should research if the colleges they are interested in require or recommend Subject Tests for admission or other purposes.

Tip

Share information about the SAT Subject Tests with other teachers at your school so they can recommend SAT Subject Tests to students who might benefit from taking these tests.

How Do Students Register for the Tests?

Students can register for the SAT Subject Tests several ways:

- On the College Board's website at collegeboard.org. Most students choose to register for Subject Tests on the College Board's website.
- By telephone (for a fee) if the student has registered previously for the SAT or an SAT Subject Test. Toll free, within the United States: 866-756-7346; from outside the United States: 212-713-7789.
- If students do not have access to the Internet, registration forms are available in *The Paper Registration Guide for the SAT and SAT Subject Tests*. Students can find the booklet in a guidance office at most high schools or by writing to:

The College Board
SAT Program
P.O. Box 025505
Miami, FL 33102

When students register for the SAT Subject Tests, they will have to indicate the specific Subject Tests they plan to take on the test date they select. Students may take one, two or three tests on any given test date; their testing fee will vary accordingly. Except for the Language Tests with Listening, students may change their minds on the day of the test and instead select from any of the other Subject Tests offered that day.

Is There a Fee-Waiver Service?

Eligible students in grades 9–12 may receive fee waivers to take up to three SAT Subject Tests in each of two sittings (up to six tests, total). These fee waivers are available in addition to those given for the SAT.

How Can Students Prepare for the Subject Tests?

There are several ways students can prepare for the SAT Subject Tests.

Regular Course Work

The best preparation for students is to learn the material taught in the classroom. The SAT Subject Tests are based on high school curricula. Later in this guide we will discuss ways you can help your students prepare throughout the year while taking your course.

Free Resources on collegeboard.org

Collegeboard.org offers a variety of information to help students prepare for the SAT Subject Tests. The site discusses topics covered on each test, recommended preparation and tips to help students do their best on test day.

Students can also prepare by using the free sample practice materials offered by the College Board at collegeboard.org/subjecttests.

Getting Ready for the SAT Subject Tests Practice Booklet

For students who don't have consistent access to the Internet, this downloadable PDF offers test-taking approaches and sample questions, with free answer explanations available online. School counselors also have access to copies of this free booklet.

Subject Test Study Guides

Official SAT Subject Test study guides are available for purchase online at sat.collegeboard.org/sat-store or in bookstores. The College Board's study guides are the only source for full-length, previously administered SAT Subject Tests. Encourage students to read the instructions before each practice test to become familiar with them before test day.

Tip

Encourage your students to explore the free practice resources on collegeboard.org/subjecttests.

What Tips Should I Give My Students Before the Test?

Some suggestions include:

- The day before the test, students should do a brief review. Cramming is typically not helpful.
- The night before the test, students should prepare what they need to take, including the admission ticket, a photo ID, two No. 2 pencils with soft erasers (no mechanical pencils), a watch and a snack. It's wise for students to double check the route to the test center, instructions for finding the entrance and the time of arrival.
- Students should arrive with plenty of time to spare.
- It's recommended that students answer the easy questions first, then move to the more difficult ones.
- Advise your students to skip the questions they cannot answer and mark them with the check in the test booklet so they can find them later.
- Students can make educated guesses on tougher questions by eliminating the answers that they know are wrong. However, if they cannot eliminate any of the answer choices, it is best to skip the question as the test penalizes random guessing.
- If your students opt to purchase a study guide, encourage them to take the practice tests with a timer set for 60 minutes. This will help students learn to pace themselves and get used to taking a one-hour test.
- Students should check their answer sheets regularly to see if the number of the question and the number of the answer match.
- It's important for students to keep track of the time.
- If they don't know every question on the test, students don't need to worry. The SAT Subject Test questions reflect what is commonly taught in high school. Due to differences in high school classes, it's likely that most students will find questions on topics they're not familiar with. Students do not have to get every question correct to receive the highest score (800) for the test. Many students do well despite not having studied every topic covered.

How Are the SAT Subject Tests Scored?

SAT Subject Tests are scored on a 200 to 800-point scale. All questions on the SAT Subject Tests are multiple choice. Each correct answer receives one point. Each incorrect answer is subtracted as follows:

- ¼ point subtracted for each five-choice question
- ⅓ point subtracted for each four-choice question
- ½ point subtracted for each three-choice question
- 0 points subtracted for questions you don't answer

Since all questions on the SAT Subject Tests in Mathematics are five-choice questions, ¼ point is subtracted for each question a student answers incorrectly. Visit collegeboard.org for additional SAT Subject Test scoring information.

Because the content measured by Level 1 and Level 2 differs considerably, students should not use their score on one test to predict their score on the other. To see how scores are distributed for each test, students can visit collegeboard.org/satpercentiles.

How Will the Students Get Their Scores?

Scores are available for free at collegeboard.org several weeks after each test is given. Students also can get their scores for a fee by telephoning customer service at 866-756-7346 in the United States and 212-713-7789 outside the United States.

Tip

Scores are also sent to high schools if students opt to share their scores with their schools. To help inform curricular planning, you can find out your students' scores by checking with your high school guidance office. Student scores are sent to the high schools approximately four weeks after students take the SAT Subject Tests.

Should a Student Take the SAT Subject Tests Again?

To help your students decide whether or not to retest, help them evaluate their scores by comparing the Subject Test score with the average scores at the colleges where they are applying or the minimum scores needed to place into a higher class or earn college credit. The two of you may decide that, with additional practice, the student could do better by taking the test again.

What Is Score Choice™?

In March 2009, the College Board introduced Score Choice™, a feature that gives students the option to choose the scores they send to colleges by test date for the SAT and by individual test for the SAT Subject Tests — at no additional cost. Designed to reduce test-day stress, Score Choice gives students an opportunity to show colleges the scores that they feel best represent their abilities.

Score Choice is optional, so if students don't actively choose to use it, all of their scores will be sent automatically with their score report. Since most colleges only consider students' best scores, students should still feel comfortable reporting scores from all of their tests.

The SAT Subject Tests in Mathematics

The SAT Subject Tests offered in Mathematics include Mathematics Level 1 and Mathematics Level 2. Students who have had preparation in trigonometry and elementary functions and have attained grades of B or better should select Mathematics Level 2.

The SAT Subject Tests in Mathematics have their own test development committee composed of high school math teachers and college professors. The test questions are written and reviewed by the SAT Subject Tests Committee, under the guidance of professional test developers. The tests are rigorously developed, highly reliable assessments of knowledge and skills taught in high school math classrooms.

Mathematics Level 1 Overview

The Mathematics Level 1 Subject Test is intended for students who have taken three years of college-preparatory mathematics, including two years of algebra and one year of geometry. Students are not expected to have studied every topic on the test.

Format

Mathematics Level 1 is a one-hour broad survey test that consists of 50 multiple-choice questions. The test has questions in the following areas:

- Number and operations
- Algebra and functions
- Geometry and measurement (plane Euclidean, coordinate geometry, three-dimensional geometry and trigonometry)
- Data analysis, statistics and probability

Mathematics Level 2 Overview

The Mathematics Level 2 Subject Test is intended for students who have taken college-preparatory mathematics for more than three years, including two years of algebra, one year of geometry, and elementary functions (precalculus) and/or trigonometry. Students are not expected to have studied every topic on the test.

Format

Mathematics Level 2 is a one-hour test that contains 50 multiple-choice questions covering the following areas:

- Number and operations
- Algebra and functions
- Geometry and measurement (coordinate geometry, three-dimensional geometry and trigonometry)
- Data analysis, statistics and probability

Helping Students Choose Between Mathematics Levels 1 and 2

If students have taken trigonometry and/or elementary functions (precalculus), received grades of B or better in these courses, and are comfortable knowing when and how to use a scientific or a graphing calculator, they should select the Level 2 test. If students are sufficiently prepared to take Level 2, but elect to take Level 1 in hopes of receiving a higher score, they may not do as well as they expect.

Students may want to consider taking the test that covers the topics they learned most recently, since the material will be fresh in their minds. They should also consider the requirements of the colleges and/or programs they are interested in. Most colleges have this information available on their websites. Students can also visit bigfuture.collegeboard.org/college-search to explore colleges and get information about their requirements.

Comparing the Two Tests

Although there is some overlap between Mathematics Levels 1 and 2, the emphasis for Level 2 is on more advanced content. Here are the differences between the two tests.

	Approximate Percentage of Test	
Topics Covered*	**Level 1**	**Level 2**
Number and Operations	**10%–14%**	**10%–14%**
Operations, ratio and proportion, complex numbers, counting, elementary number theory, matrices, sequences, *series, vectors*		
Algebra and Functions	**38%–42%**	**48%–52%**
Expressions, equations, inequalities, representation and modeling, properties of functions (linear, polynomial, rational, exponential, *logarithmic, trigonometric, inverse trigonometric, periodic, piecewise, recursive, parametric)*		
Geometry and Measurement	**38%–42%**	**28%–32%**
Plane Euclidean/Measurement	**18%–22%**	**—**
Coordinate	**8%–12%**	**10%–14%**
Lines, parabolas, circles, *ellipses, hyperbolas,* symmetry, transformations, *polar coordinates*		
Three-dimensional	**4%–6%**	**4%–6%**
Solids, surface area and volume (cylinders, cones, pyramids, spheres, prisms), *coordinates in three dimensions*		
Trigonometry	**6%–8%**	**12%–16%**
Right triangles, identities, *radian measure, law of cosines, law of sines, equations, double angle formulas*		
Data Analysis, Statistics and Probability	**8%–12%**	**8%–12%**
Mean, median, mode, range, interquartile range, *standard deviation,* graphs and plots, least-squares regression (linear, *quadratic, exponential),* probability		

* Topics in italics are tested on Level 2 only.

The content of Level 1 overlaps somewhat with that of Level 2, but the emphasis on Level 2 is on more advanced content. Plane Euclidean geometry is not tested directly on Level 2.

Areas of Overlap

The content of Level 1 has some overlap with Level 2, especially in the following areas:

- Elementary algebra
- Three-dimensional geometry
- Coordinate geometry
- Statistics
- Basic trigonometry

How Test Content Differs

Although some questions may be appropriate for both tests, the emphasis for Level 2 is on more advanced content. The tests differ significantly in the following areas:

Number and Operations: Level 1 measures a more basic understanding of the topics than Level 2. For example, Level 1 covers the arithmetic of complex numbers, but Level 2 also covers graphical and other properties of complex numbers. Level 2 also includes series and vectors.

Algebra and Functions: Level 1 contains mainly algebraic equations and functions, whereas Level 2 also contains more advanced equations and functions, such as exponential, logarithmic and trigonometric.

Geometry and Measurement: A significant percentage of the questions on Level 1 is devoted to plane Euclidean geometry and measurement, which is not tested directly on Level 2. In Level 2, the concepts learned in plane geometry are applied in the questions on coordinate geometry and three-dimensional geometry.

The trigonometry questions on Level 1 are primarily limited to right triangle trigonometry (sine, cosine, tangent) and the fundamental relationships among the trigonometric ratios. Level 2 includes questions about ellipses, hyperbolas, polar coordinates and coordinates in three dimensions. The trigonometry questions on Level 2 place more emphasis on the properties and graphs of trigonometric functions, the inverse trigonometric functions, trigonometric equations and identities and the laws of sines and cosines.

Data Analysis, Statistics and Probability: Both Level 1 and Level 2 include mean, median, mode, range, interquartile range, data interpretation, and probability. Level 2 also includes standard deviation. Both include least-squares linear regression, but Level 2 also includes quadratic and exponential regression.

Helping Your Students Prepare for the Test

Classroom Preparation

Course work is the most important part of preparing for SAT Subject Tests. Before students take one of the Subject Tests in Mathematics, they should have completed appropriate course work. Please see the previous section of this guide (page 10) for specific courses recommended prior to taking these tests.

Preparation and Practice

Encourage your students to get ready by working on the free sample practice questions on the College Board's website at collegeboard.org/subjecttests. Additional practice materials are available for purchase in bookstores or online at sat.collegeboard.org/sat-store.

Tip

Remind your students to take the practice tests with the calculator that they will use on test day.

Calculator Use

While it is not necessary to use a calculator to solve every question on either test, it is important that your students know when and how to use one. Students who take the test without a calculator will be at a disadvantage.

In Level 1, using the calculator gives no advantage and may be a disadvantage for about 50 to 60 percent of the questions. For about 40 to 50 percent of the questions, a calculator may be useful or necessary.

In Level 2, using the calculator gives no advantage for about 35 to 45 percent of the questions. It may be useful for about 55 to 65 percent of them.

A graphing calculator may provide an advantage over a scientific calculator on some questions. However, students should bring the calculator with which they are most familiar. If students are comfortable with both a scientific calculator and a graphing calculator, they should bring the graphing calculator.

General Calculator Policy: Students may not use a calculator on any Subject Test other than the Mathematics Level 1 and Level 2 Tests.

Tips for Calculator Use

- Before students take the test, they should make sure that their calculator is in good working order. Students may bring batteries and a backup calculator to the test center.
- The test center will not have substitute calculators or batteries on hand.
- If a student's calculator malfunctions during one of the Mathematics Level 1 or Level 2 Tests and he or she does not have a backup calculator, the student must tell his test supervisor when the malfunction occurs. The supervisor will then cancel the scores on that test only, if the student desires to do so.

Which Calculators Are NOT Permitted

- Calculators that have QWERTY keypads (e.g., TI-92 Plus, Voyage 200) or have pen-input stylus,* or touch-screen capability (e.g., PDAs, Casio Class Pad).
- Calculators that have wireless, Bluetooth, cellular, audio/video recording and playing, camera, or any other cell phone–type feature.
- Calculators that make noise or "talk," require an electrical outlet, or use paper tape.
- Calculators that can access the Internet.
- Laptops, portable handheld computers, electronic writing pads or pocket organizers.

* The use of the stylus with the Sharp EL-9600 calculator will not be permitted. The Sharp EL-9600 remains on the list of approved graphing calculators.

Prior to test day, make sure to check www.collegeboard.org for the latest information and policies on calculators.

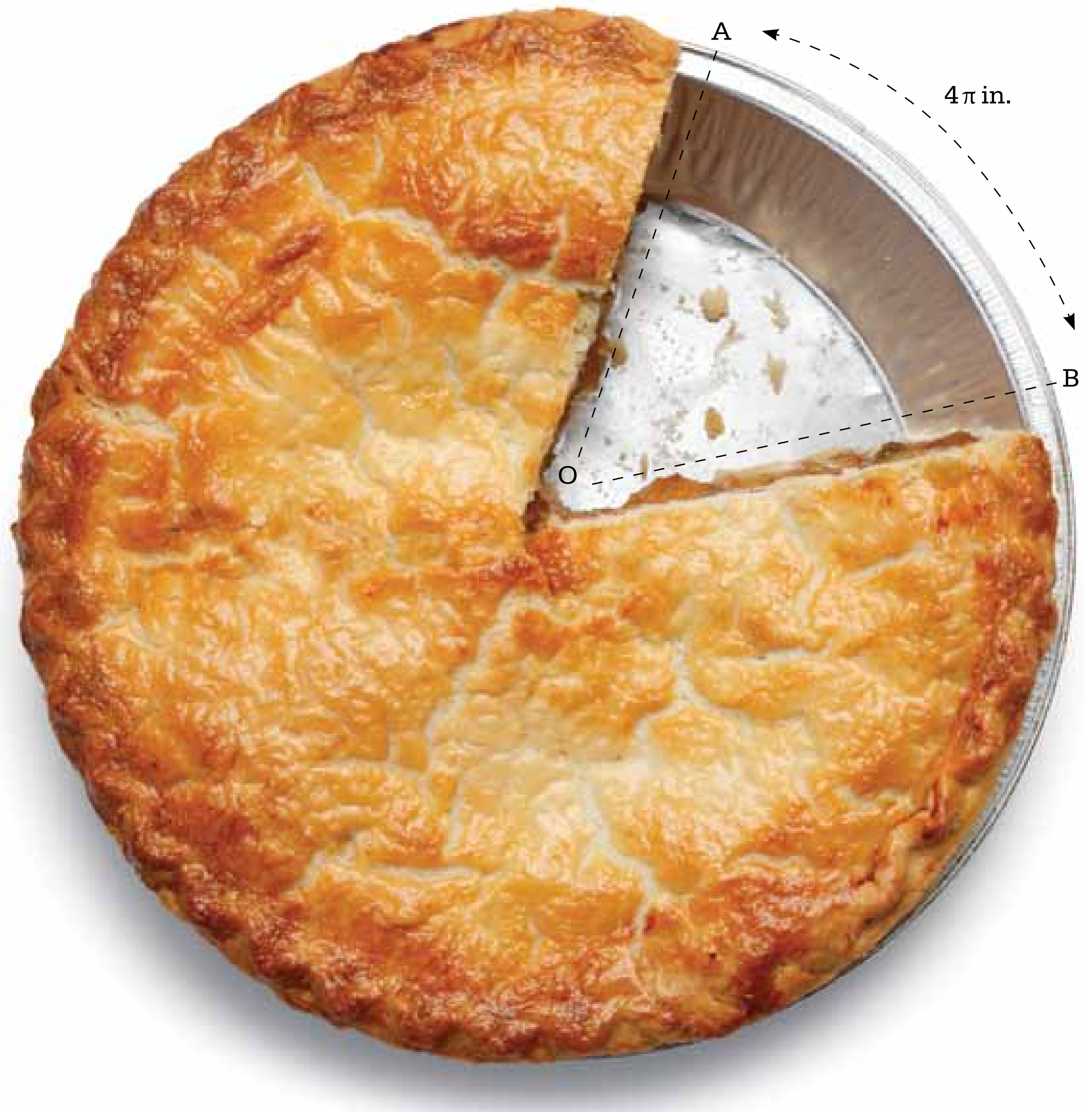
Helping Students Get the Most Out of Their Calculators

- Not all questions on these tests require the use of a calculator. Advise your students **to only pick up a calculator if they need to** — otherwise they might waste time.
- **The answer choices are often rounded**, so the answers students get might not match the answers in their test books.
- **Don't round any intermediate calculations**. For example, if a student gets a result from his calculator for the first step of a solution, he should keep the result in the calculator and use it for the second step before rounding the numbers.
- **Read the question carefully. This will help your students** know what they are being asked to do. Sometimes a result that the student may get from his or her calculator is not the final answer.
- Students taking the **Level 1 test should make sure their calculator is in degree mode** ahead of time so they won't have to worry about it during the test. If they're taking the Level 2 test, students should make sure their calculator is in the correct mode (degree or radian) for the question being asked.
- For some questions on these tests, a **graphing calculator** may provide an advantage. If students use a graphing calculator, they should know how to perform calculations (e.g., exponents, roots, trigonometric values, logarithms), graph functions and analyze the graphs, find zeros of functions, find points of intersection of graphs of functions, find minima/maxima of functions, find numerical solutions to equations, generate a table of values for a function, and perform data analysis features, including finding a regression equation.
- **Students are not allowed to share calculators**. They will be dismissed and their scores canceled if students use their calculators to share information during the test or to remove test questions or answers from the test room.

Geometric Figures

Figures that accompany problems are intended to provide information useful in solving the problems. They are drawn as accurately as possible except when it is stated in a particular problem that the figure is not drawn to scale. Even when figures are not drawn to scale, the relative positions of points and angles may be assumed to be in the order shown. Also, line segments that extend through points and appear to lie on the same line may be assumed to be on the same line.

When "Note: Figure not drawn to scale," appears below a figure in a question, it means that degree measures may not be accurately shown and specific lengths may not be drawn proportionately.



Mathematics Level 1

Sample Questions and Answer Explanations

Math Level 1

Reference Information

THE FOLLOWING INFORMATION IS FOR YOUR REFERENCE IN ANSWERING SOME OF THE SAMPLE QUESTIONS. THIS INFORMATION IS ALSO PROVIDED ON THE ACTUAL SUBJECT TEST IN MATHEMATICS LEVEL 1.

Volume of a right circular cone with radius r and height h: $V = \frac{1}{3}\pi r^2 h$

Volume of a sphere with radius r: $V = \frac{4}{3}\pi r^3$

Volume of a pyramid with base area B and height h: $V = \frac{1}{3}Bh$

Surface Area of a sphere with radius r: $S = 4\pi r^2$

Directions: For each of the following problems, decide which is the BEST of the choices given. If the exact numerical value is not one of the choices, select the choice that best approximates this value. Then fill in the corresponding circle on the answer sheet.

Notes:

1) A scientific or graphing calculator will be necessary for answering some (but not all) of the questions in this test. For each question you will have to decide whether or not you should use a calculator.
2) The only angle measure used in this test is degree measure. Make sure your calculator is in the degree mode.
3) Figures that accompany problems in this test are intended to provide information useful in solving the problems. They are drawn as accurately as possible EXCEPT when it is stated in a specific problem that the figure is not drawn to scale. All figures lie in a plane unless otherwise indicated.
4) Unless otherwise specified, the domain of any function f is assumed to be the set of all real numbers x for which $f(x)$ is a real number. The range of f is assumed to be the set of all real numbers $f(x)$, where x is in the domain of f.
5) Reference information that may be useful in answering the questions in this test can be found on this page.

NUMBERS AND OPERATIONS

1. The 3rd term of a geometric sequence is -3, and the 6th term is $\frac{3}{8}$. What is the 4th term of the sequence?

A) $-\frac{1}{2}$

B) $-\frac{3}{2}$

C) $\frac{3}{4}$

D) $\frac{3}{2}$

E) 3

2. In how many integers between 99 and 1,000 does 7 appear exactly once as a digit?

A) 221

B) 225

C) 234

D) 243

E) 252

Answers and Explanations

1. Correct Answer: D

Explanation: Choice (D) is the correct answer. By definition, each term after the first in a geometric sequence is r times the previous term for some constant r. Since the 3rd term of this sequence is -3, it follows that the 4th term can be written as $-3r$, the 5th term as $-3r^2$, and the 6th term as $-3r^3$. The 6th term is given as $\frac{3}{8}$, so $-3r^3 = \frac{3}{8}$. It follows that $r^3 = -\frac{1}{8}$. Solving for r gives $r = -\frac{1}{2}$. The 4th term of the sequence is then $-3r = (-3)\left(-\frac{1}{2}\right) = \frac{3}{2}$.

Tip

To approach this problem, have students consider the definition of a geometric sequence along with the information given in the question so that they can begin to write some equations.

2. Correct Answer: B

Explanation: Choice (B) is the correct answer. Each integer between 99 and 1,000 that has 7 appearing exactly once is a three-digit number in which 7 will be in exactly one of these three positions: (a) hundreds, (b) tens or (c) ones.

Consider first the set of all three-digit integers that have 7 appearing exactly once, in the hundreds position. There are 9 one-digit numbers other than 7 that can be placed in the tens position and there are also 9 one-digit numbers other than 7 that can be placed in the ones position, giving a total of (9)(9) = 81 three-digit numbers with 7 only in the hundreds position.

Consider now the set of all three-digit numbers that have 7 only in the tens position. There are 8 one-digit numbers other than 7 that can be placed in the hundreds position (0 is excluded) and 9 one-digit numbers other than 7 that can be placed in the ones position, giving a total of (8)(9) = 72 three-digit numbers that have 7 only in the tens position.

Finally, consider the set of all three-digit numbers that have 7 only in the ones position. There are 8 one-digit numbers other than 7 that can be placed in the hundreds position (0 is excluded) and 9 one-digit numbers other than 7 that can be placed in the tens position, giving a total of (8)(9) = 72 three-digit numbers that have 7 only in the ones position.

The sets of numbers in all the cases discussed above do not overlap with each other. Hence, the total number of integers between 99 and 1,000 in which 7 appears exactly once as a digit is 81 + 72 + 72 = 225.

Tip

Students can take various approaches to solving this problem, but whatever method they choose, they should be systematic and careful not to "double count." Students should also be careful not to spend too much time on a problem like this one or on any problem.

3. **An artist constructed a sculpture consisting of five vertical bars placed 3 inches apart from each other along a straight line from left to right on level ground. The height of the leftmost bar was 52.00 inches, and the height of each of the other bars was 60 percent of the height of the bar immediately to its left. What was the height, in inches, of the 4th bar from the left?**

A) 6.74

B) 11.23

C) 13.33

D) 18.72

E) 33.28

4. **If $t^3 + 2 = 12$, what is the value of t?**

A) 1.59

B) 1.82

C) 2.15

D) 2.29

E) 2.41

5. **If $a^{\frac{3}{4}} = 27$, what is the value of $a^{\frac{1}{2}}$?**

A) 3

B) 6

C) 9

D) 18

E) 81

3. **Correct Answer: B**

Explanation: Choice (B) is the correct answer. The height of each bar was 60 percent of the height of the bar immediately to its left, so the height of the 2nd bar from the left was 60 percent of 52.00 inches, or $(0.6)(52) = 31.20$ inches. The height of the 3rd bar from the left was then $(0.6)(31.20) = 18.72$ inches, and the height of the 4th bar from the left was $(0.6)(18.72) = 11.23$ inches.

Tip

Students might find it useful to draw a sketch using the information in the description of the sculpture.

4. **Correct Answer: C**

Explanation: Choice (C) is the correct answer. The answer choices indicate that the calculator will be necessary or at least useful in solving this equation. The equation $t^3 + 2 = 12$ is equivalent to $t^3 = 10$. Since $\sqrt[3]{t^3} = t$, the value of t is $\sqrt[3]{10} = 2.1544$, which rounds to 2.15.

Tip

Given the form of the answers, students should expect that the calculator may be necessary or at least useful in solving this equation.

5. **Correct Answer: C**

Explanation: Choice (C) is the correct answer. Solve $a^{\frac{3}{4}} = 27$ for a by raising both sides of the equation to the power $\frac{4}{3}$ yielding $a = 27^{\frac{4}{3}} = \left(\sqrt[3]{27}\right)^4$, so $a = 81$. Then substitute $a = 81$ in $a^{\frac{1}{2}}$ and simplify $81^{\frac{1}{2}} = \sqrt{81} = 9$.

Tip

Students should remember that they can transform quantities with rational number exponents into radicals if necessary.

6. If $4a - b = 7b + 11a$ and $ab \neq 0$, what is the ratio of a to b ?

A) -1.14

B) -0.88

C) 0.88

D) 1.14

E) 1.85

7. Which of the following equations is consistent with the relationship between x and y in the table to the right?

A) $y = 12|x + 1|$

B) $y = 3(3 - x)$

C) $y = 3(1 - x^2)$

D) $y = 3(x - 1)^2$

E) $y = 3(x^2 + 1)$

x	y
–1	12
0	3
1	0
3	12
5	48

6. **Correct Answer: A**
Explanation: Choice (A) is the correct answer. The equation $4a - b = 7b + 11a$ is equivalent to $-7a = 8b$, which is equivalent to $a = -\frac{8}{7}b$. Since $ab \neq 0$, both sides of this equation can be divided by b to give $\frac{a}{b} = -\frac{8}{7} \approx -1.1429$, which rounds to -1.14. Therefore, the ratio of a to b is -1.14.

7. **Correct Answer: D**
Explanation: Choice (D) is the correct answer. The equation in option (A) is not consistent with the relationship between x and y in the table above because it becomes false for the first pair (x, y) in the table: $12 \neq 12\left|-1 + 1\right| = 0$.

The equation in option (B) is not consistent with the relationship between x and y in the table above because it becomes false for the second pair (x, y) in the table: $3 \neq 3(3 - 0) = 9$.

The equation in option (C) is not consistent with the relationship between x and y in the table above because it becomes false for the first pair (x, y) in the table: $12 \neq 3\left(1 - (-1)^2\right) = 0$.

The equation in option (E) is not consistent with the relationship between x and y in the table above because it becomes false for the first pair (x, y) in the table: $12 \neq 3\left((-1)^2 + 1\right) = 6$.

Finally, there is no pair (x, y) in the table shown above for which the equation in option (D) becomes false. Therefore, the equation in (D) is consistent with the relationship between x and y in the table.

Tip

Students should remember that to show that an equation is not consistent with the relationship given in the table, it is enough to find one pair (x, y) in the table for which the equation becomes false.

ALGEBRA AND FUNCTIONS: REPRESENTATION AND MODELING

8. **For the first printing of a book, a publisher prints 10,000 copies, and for each subsequent printing, the publisher prints 5,000 copies. Which of the following represents the total number of copies in *n* printings?**

   A) $5{,}000(n-2)$

   B) $5{,}000(n-1)$

   C) $5{,}000n$

   D) $5{,}000(n+1)$

   E) $5{,}000(n+2)$

9. **A person's weight on the moon is directly proportional to the person's weight on Earth. If a person who weighs 144 pounds on Earth weighs 24 pounds on the moon, how many pounds does a person who weighs 114 pounds on Earth weigh on the moon?**

   A) 13

   B) 15

   C) 17

   D) 19

   E) 21

8. Correct Answer: D

Explanation: Choice (D) is the correct answer. The total number of copies can be represented by $10{,}000 + 5{,}000(n - 1)$. This simplifies to $5{,}000n + 5{,}000$ or $5{,}000(n + 1)$.

Tip

Students should choose the formula that is consistent with the total number of copies for $n = 1$ and $n = 2$.

9. Correct Answer: D

Explanation: Choice (D) is the correct answer. Let x pounds be the weight on the moon of the person whose weight on Earth is 114 pounds. Since a person's weight on the moon is directly proportional to the person's weight on Earth, and a person who weighs 144 pounds on Earth weighs 24 pounds on the moon, it follows that $\frac{144}{24} = \frac{114}{x}$. Hence, $144x = (114)(24)$, and so $x = 19$. Therefore, a person who weighs 114 pounds on Earth weighs 19 pounds on the moon.

Tip

In a problem involving proportional reasoning, students should use the information in the problem to set up a proportion relating the known and unknown quantities.

ALGEBRA AND FUNCTIONS: FUNCTIONS AND THEIR PROPERTIES

10. If $f(t)=\dfrac{3}{t^3-1}$, what is the value of $f(-3)$?

A) -0.115

B) -0.111

C) -0.107

D) 0.107

E) 0.115

11. If f is a function defined by $f(x) = 8x - 3$, and if f^{-1} is the inverse function of f, then $f^{-1}(x) =$

A) $3x-8$

B) $\dfrac{x-8}{3}$

C) $\dfrac{x-3}{8}$

D) $\dfrac{x+8}{3}$

E) $\dfrac{x+3}{8}$

12. In the xy-plane, the graph of $y = x^3 - 12x^2 + 25x + 3$ intersects the graph of $y = 19$ in how many points?

A) None

B) One

C) Two

D) Three

E) Four

10. Correct Answer: C

Explanation: Choice (C) is the correct answer. If $f(t) = \dfrac{3}{t^3 - 1}$, then $f(-3) = \dfrac{3}{(-3)^3 - 1} = \dfrac{3}{-27 - 1} = \dfrac{3}{-28} \approx -0.107$.

Tip

Students may find a calculator helpful in solving this problem, but it can also be done without a calculator.

11. Correct Answer: E

Explanation: Choice (E) is the correct answer. Solving the equation $y = 8x - 3$ for x gives $x = \dfrac{y+3}{8}$. Interchanging x and y yields $y = \dfrac{x+3}{8}$. Therefore, the inverse function of f is $f^{-1}(x) = \dfrac{x+3}{8}$.

Alternatively, thinking of a function as a sequence of operations performed in a certain order on an input, the inverse function would be the sequence of inverse operations (undoing), performed in the reverse order. Hence, since f is first multiplying the input by 8, and then subtracting 3, f^{-1} will first add 3 to the input, and then divide by 8, that is, $f^{-1}(x) = \dfrac{x+3}{8}$.

Tip

Students can think of f as a sequence of operations on an input, and then the inverse f^{-1} will be the sequence of inverse operations, in reverse order. Also, students can pick an input value, say $x = 5$, and evaluate $f(5) = 37$. They can then check their answer by evaluating $f^{-1}(37)$ to see if they get 5.

12. Correct Answer: B

Explanation: Choice (B) is the correct answer. The number of points of intersection of the graphs of $y = x^3 - 12x^2 + 25x + 3$ and $y = 19$ will be visible when both equations are graphed on a graphing calculator. It is important to choose appropriate bounds on the viewing window to see this. For example, if $-5 < x < 12$ and $-10 < y < 20$, it will be clear that the only point of intersection of the two graphs occurs near the point (9.56, 19). Thus, the two graphs intersect in one point.

Tip

In using a graphing calculator to solve problems, students should be reminded that it is important how they select the viewing window.

GEOMETRY AND MEASUREMENT: PLANE EUCLIDEAN GEOMETRY

13. Points P, Q, R and S lie on a line in that order. If $\overline{PR}$ has length 12, $\overline{QS}$ has length 17, and $\overline{PQ}$ has length 4, what is the length of $\overline{RS}$?

A) 7

B) 9

C) 11

D) 13

E) It cannot be determined from the information given.

14. The rectangle in the figure to the right has area 12. Solving which of the following equations gives the value of x?

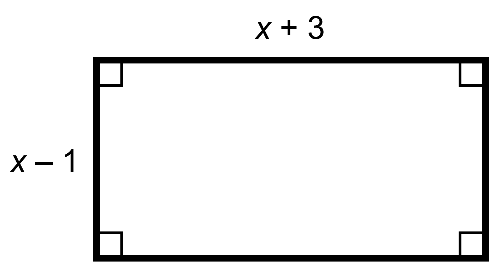
A) $x^2 - 15 = 0$

B) $x^2 - 2x = 0$

C) $x^2 - 2x - 12 = 0$

D) $x^2 + 2x - 3 = 0$

E) $x^2 + 2x - 15 = 0$

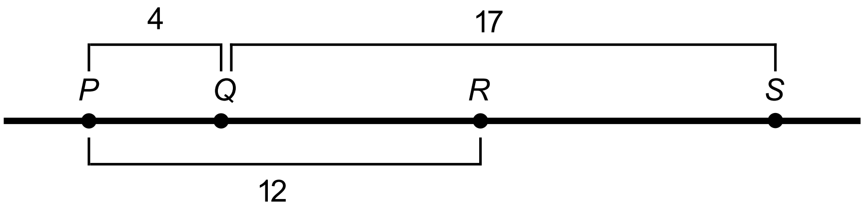


Note: Figure not drawn to scale.

Answers and Explanations

13. Correct Answer: B

Explanation: Choice (B) is the correct answer. It may be helpful to draw the following picture:



From the figure, it can be seen that $RS = QS - QR$. The length of $\overline{QS}$ is given as 17, so the length of $\overline{RS}$ can be found if the length of $\overline{QR}$ can be determined. Since $QR = PR - PQ$, it follows that $QR = 12 - 4 = 8$. Therefore, $RS = QS - QR = 17 - 8 = 9$.

Tip

Drawing a figure can be helpful to students who are solving a geometry problem in which no figure is given.

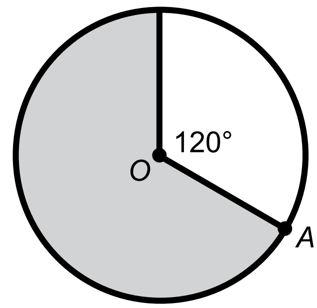
14. Correct Answer: E

Explanation: Choice (E) is the correct answer. Since the width and length of the rectangle are $x - 1$ and $x + 3$, respectively, and the rectangle has area 12, it follows that $(x - 1)(x + 3) = 12$. Multiplying out the left side of the equation yields $x^2 + 2x - 3 = 12$, or equivalently $x^2 + 2x - 15 = 0$.

Tip

When measurements in a figure, such as side lengths, are given in terms of a variable, students may be able to write other measurements, such as area, in terms of the same variable.

15. The circle in the figure to the right has center O, and the area of the shaded region is 24π. What is the length of segment $\overline{OA}$?



A) 4

B) 6

C) 8

D) 9

E) 12

16. Which of the following CANNOT be the lengths of the sides of a triangle?

A) 1, 2 and 2

B) 2, 2 and 3

C) 2, 2 and 4

D) 2, 3 and 3

E) 2, 3 and 4

Answers and Explanations

15. Correct Answer: B

Explanation: Choice (B) is the correct answer. Segment $\overline{OA}$ is a radius of the circle, so the square of OA multiplied by π is equal to the area of the circle. The unshaded region of the circle has a central arc of 120º, and the entire circle has 360º of arc, so the unshaded region of the circle represents $\frac{120}{360} = \frac{1}{3}$ of the entire circular region. Therefore, 24π, the area of the shaded region, represents $\frac{2}{3}$ of the area of the circle or $\frac{2}{3}\pi r^2 = 24\pi$.

Solving this equation gives $r = OA = 6$.

Tip

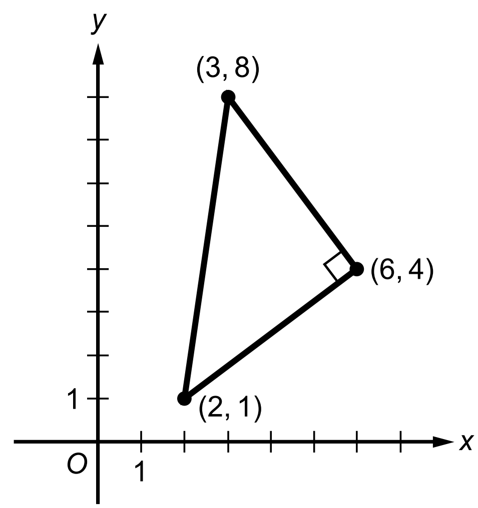
When solving geometric problems with figures, students should mark up the figure with what they know from the information given in the problem.

16. Correct Answer: C

Explanation: Choice (C) is the correct answer. In any triangle, the length of any side is less than the sum of the lengths of the other two sides. If the lengths of the sides of a triangle were 2, 2 and 4, and this condition would not be satisfied, because 4 = 2 + 2. Therefore, 2, 2 and 4 cannot be the lengths of the sides of a triangle.

GEOMETRY AND MEASUREMENT: COORDINATE GEOMETRY

17. What is the area of the right triangle in the xy-plane to the right?



A) 10.5

B) 12.5

C) 13

D) 13.5

E) 15

18. In the xy-plane, the point $(c,0)$ is on the graph of $y=x^4-3x^3+8x^2$. How many possible values are there for c?

A) One

B) Two

C) Three

D) Four

E) More than four

19. In the xy-plane, what is the equation of the axis of symmetry of the graph of $y=x^2-11x+24$?

A) $x=-11$

B) $x=-5.5$

C) $x=4$

D) $x=5.5$

E) $x=11$

17. Correct Answer: B

Explanation: Choice (B) is the correct answer. The area of a right triangle is one-half the product of the length of its legs. The lengths of the legs of the given triangle can be found using the distance formula. The length of the leg with endpoints (3, 8) and (6, 4) is $\sqrt{(6-3)^2+(4-8)^2}$, which simplifies to $\sqrt{3^2+(-4)^2}=\sqrt{9+16}=\sqrt{25}=5$. The length of the leg with endpoints (2, 1) and (6, 4) is $\sqrt{(6-2)^2+(4-1)^2}$, which simplifies to $\sqrt{4^2+3^2}=\sqrt{16+9}=\sqrt{25}=5$. Therefore, the area of the triangle is $\frac{(5)(5)}{2}=\frac{25}{2}=12.5$.

Tip

If students know the coordinates of the endpoints of a line segment in the *xy*-plane, they can use the distance formula to find the length of the segment.

18. Correct Answer: A

Explanation: Choice (A) is the correct answer. Since the point $(c,0)$ is on the graph of $y=x^4-3x^3+8x^2$, it follows that c must be a real number solution to $c^4-3c^3+8c^2=0$. Thus, the number of possible values for c is the same as the number of real number solutions to $c^4-3c^3+8c^2=0$. Factoring out c^2 on the left side of the equation yields $c^2\left(c^2-3c+8\right)=0$. It follows that $c^2=0$ or $c^2-3c+8=0$. The first equation has only one real solution, $c=0$, whereas the second equation has no real solutions. Therefore, there is only one possible value for c. Alternatively, if a graphing calculator is used to graph $y=x^4-3x^3+8x^2$, one can see in how many points the graph intersects the x-axis and reach the same conclusion.

Tip

Students can sometimes use a graphing calculator to determine how many solutions an equation has without finding the exact solutions.

19. Correct Answer: D

Explanation: Choice (D) is the correct answer. The graph in the xy-plane of the quadratic function $y=x^2-11x+24$ is a parabola that opens upward. The x-intercepts of the graph can be found by solving the equation $x^2-11x+24=0$. This equation has solutions $x=3$ and $x=8$. It follows that the graph of the equation crosses the x-axis at the points (3,0) and (8,0). The axis of symmetry of the parabola crosses the x-axis at the point halfway between(3,0) and (8,0), which is $\left(\frac{3+8}{2},0\right)=(5.5,0)$. The axis of symmetry is the line perpendicular to the x-axis through this point, so the equation of the axis of symmetry is $x=5.5$.

GEOMETRY AND MEASUREMENT: THREE-DIMENSIONAL GEOMETRY

20. A sphere of radius 2 inches is inscribed in a cube. What is the volume, in cubic inches, of the cube?

A) 8

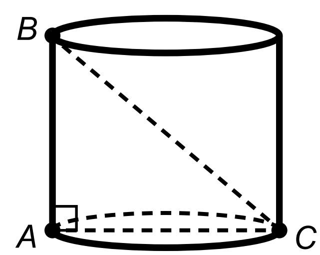
B) $8\sqrt{2}$

C) $16\sqrt{2}$

D) $32\sqrt{2}$

E) 64

21. The right circular cylinder in the figure to the right has height 3 inches and volume 48π cubic inches, and segment $\overline{AC}$ is a diameter of the base. What is the area, in square inches, of triangle ABC?



Note: Figure not drawn to scale.

A) 6

B) 8

C) 12

D) 16

E) 24

Answers and Explanations

20. Correct Answer: E

Explanation: Choice (E) is the correct answer. When a sphere is inscribed in a cube, the six points of tangency of the sphere and the cube are the centers of the six faces of the cube. Each of the segments joining the centers of two opposite faces of the cube is a diameter of the sphere. Each of these segments is parallel to four edges of the cube, and so the edges of the cube have the same length as the diameters of the sphere. The radius of the sphere is 2 inches, so the diameter is 4 inches. Therefore, an edge of the cube has a length of 4 inches, so the volume of the cube is $4^3 = 64$ cubic inches.

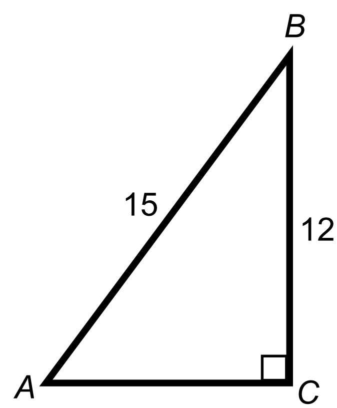
21. Correct Answer: C

Explanation: Choice (C) is the correct answer. Since the volume of the right circular cylinder is 48π cubic inches, and the formula for the volume, V, of a right circular cylinder with base radius r and height h is $V = \pi r^2 h$, it follows that $\pi r^2(3) = 48\pi$. Solving this equation for r gives $r = 4$ inches, and so the diameter of the base of the cylinder, AC, must be 8 inches. Then the area of the right triangle ABC is half the product of its two legs, AB and AC Since the height of the cylinder is 3 inches, $AB = 3$ inches. Therefore, the area of triangle ABC is $\frac{(8)(3)}{2} = 12$ square inches.

Tip

Students can use a formula, such as that for the volume of a right circular cylinder, to find any of the unknowns in the formula, such as the height or the base radius, given values of the other unknowns.

GEOMETRY AND MEASUREMENT: TRIGONOMETRY



22. In the triangle above, $\tan A = \frac{4}{3}$. What is $\sin B$?

A) $\frac{3}{5}$

B) $\frac{3}{4}$

C) $\frac{4}{5}$

D) $\frac{5}{4}$

E) $\frac{4}{3}$

23. The stem-and-leaf plot to the right gives the ages, in years, of the nine employees in an office. What is the median age of the nine employees?

A) 31

B) 32

C) 35

D) 37

E) 38

AGES OF EMPLOYEES

2	6	8		
3	1	1	7	8
4	0	2	6	

Note: 2|6 represents 26

22. Correct Answer: A

Explanation: Choice (A) is the correct answer. Since $\tan A = \frac{4}{3}$ is equal to $\frac{BC}{AC}$, and $BC = 12$, it follows that $\frac{12}{AC} = \frac{4}{3}$. Hence, $AC = \frac{(12)(3)}{4} = 9$. Therefore, $\sin B = \frac{AC}{AB} = \frac{9}{15} = \frac{3}{5}$.

Tip

Students can use various approaches to solve this problem, including using a calculator to find the degree measure of angle *B* and then to find sin *B*.

23. Correct Answer: D

Explanation: Choice (D) is the correct answer. According to the stem-and-leaf plot, the ages of the nine employees are 26, 28, 31, 31, 37, 38, 40, 42, and 46. These ages are listed in increasing order, so the median of these ages is the middle number in the list. Therefore, the median age of the nine employees is 37.

Tip

Students either can use a data display directly to calculate a quantity such as the median, or they can re-express the data in its original form and then calculate the quantity.

24. The average (arithmetic mean) of a list of 12 numbers is 10. Two of the numbers are removed, and the average of the remaining numbers is 8. What is the sum of the two numbers that were removed?

A) 24

B) 27

C) 30

D) 36

E) 40

25. Of the 50 boxes of cereal on a supermarket shelf, 2 percent contain a prize. If Christina buys three boxes of the cereal, what is the probability that none of the boxes she buys will contain a prize?

A) $\frac{47}{50}$

B) $\frac{48}{50}$

C) $\frac{49}{50}$

D) $\left(\frac{49}{50}\right)^2$

E) $\left(\frac{49}{50}\right)^3$

Answers and Explanations

24. Correct Answer: E

Explanation: Choice (E) is the correct answer. Since the average (arithmetic mean) of the 12 numbers in the list is 10, it follows that the sum of the 12 numbers is $(12)(10) = 120$. Since the average of the 10 remaining numbers is 8, it follows that their sum is $(10)(8) = 80$. Hence the sum of the 2 numbers that were removed must be $120 - 80 = 40$.

Tip

If students know how many numbers are in a list, they can find the sum of the numbers from the average, or the average of the numbers from the sum.

25. Correct Answer: A

Explanation: Choice (A) is the correct answer. Of the 50 boxes of cereal, one box contains a prize because 2 percent of 50 is 1. Hence 49 of the 50 boxes do not contain a prize. It follows that the probability that there will not be a prize in the first box of cereal Christina buys is $\frac{49}{50}$. If the first box she buys contains no prize, then 48 of the remaining 49 boxes will contain no prize, so the probability that there will not be a prize in either of the first two boxes is $\left(\frac{49}{50}\right)\left(\frac{48}{49}\right)$. Finally, if the first two boxes Christina buys contain no prize, then 47 of the remaining 48 boxes will contain no prize. Therefore, the probability that none of the three boxes she buys will contain a prize is $\left(\frac{49}{50}\right)\left(\frac{48}{49}\right)\left(\frac{47}{48}\right) = \frac{47}{50}$.

Tip

Depending on the problem, students may be able to analyze and solve probability questions about choosing several items from a set by considering the choice of each item in turn or by considering all the items to be chosen at the same time.

Mathematics Level 2

Mathematics Level 2

Sample Questions and Answer Explanations

Math Level 2

Reference Information

THE FOLLOWING INFORMATION IS FOR YOUR REFERENCE IN ANSWERING SOME OF THE SAMPLE QUESTIONS. THIS INFORMATION IS ALSO PROVIDED ON THE ACTUAL SUBJECT TEST IN MATHEMATICS LEVEL 2.

Volume of a right circular cone with radius r and height h: $V = \frac{1}{3}\pi r^2 h$

Volume of a sphere with radius r: $V = \frac{4}{3}\pi r^3$

Volume of a pyramid with base area B and height h: $V = \frac{1}{3}Bh$

Surface Area of a sphere with radius r: $S = 4\pi r^2$

Directions: For each of the following problems, decide which is the BEST of the choices given. If the exact numerical value is not one of the choices, select the choice that best approximates this value. Then fill in the corresponding circle on the answer sheet.

Notes:

1) A scientific or graphing calculator will be necessary for answering some (but not all) of the questions in this test. For each question you will have to decide whether or not you should use a calculator.
2) For some questions in this test you may have to decide whether your calculator should be in the radian mode or the degree mode.
3) Figures that accompany problems in this test are intended to provide information useful in solving the problems. They are drawn as accurately as possible EXCEPT when it is stated in a specific problem that its figure is not drawn to scale. All figures lie in a plane unless otherwise indicated.
4) Unless otherwise specified, the domain of any function f is assumed to be the set of all real numbers x for which $f(x)$ is a real number. The range of f is assumed to be the set of all real numbers $f(x)$, where x is in the domain of f.
5) Reference information that may be useful in answering the questions in this test can be found on this page.

NUMBERS AND OPERATIONS

1. **If n is divisible by both 2 and 7, then n is divisible by 28.**

   Which of the following values of n shows that the statement above is <u>false</u>?

   A) 28

   B) 32

   C) 42

   D) 52

   E) 56

2. **The 3rd term of an arithmetic sequence is 8, and the 7th term is 18. What is the 5th term of the sequence?**

   A) 11.5

   B) 12

   C) 12.5

   D) 13

   E) 15.5

3. **In a jewelry design, 7 beads, each of a different color (red, pink, blue, white, black, brown and beige), are to be arranged in order from left to right on a chain. If the black bead and the brown bead must be at the ends of the chain, how many different orderings of the beads are possible?**

   A) $5!$

   B) $7!$

   C) $2 \cdot 5!$

   D) $2 \cdot 7!$

   E) $\frac{7!}{2}$

Answers and Explanations

1. Correct Answer: C

Explanation: Choice (C) is the correct answer. The number 42 is divisible by both 2 and 7, and thus 42 satisfies the hypothesis of the given statement. However, 42 is <u>not</u> divisible by 28, and thus 42 is a counterexample that shows the given statement is <u>false</u>.

Tip

Students should remember that a counterexample, which shows that a statement is <u>false</u>, must satisfy the hypothesis of the statement, yet fail to meet its conclusion.

2. Correct Answer: D

Explanation: Choice (D) is the correct answer. In an arithmetic sequence, the difference between any two consecutive terms is the same. Let d be this difference for the arithmetic sequence above. Then the difference between the 7th term and the 3rd term is $(7-3)d = 4d$. Since the 7th term is 18 and the 3rd term is 8, it follows that $18 - 8 = 4d$, or equivalently, $2d = 5$. The 5th term of the sequence can be found by adding $2d$ to the 3rd term of the sequence. Hence, the 5th term of the sequence is $8 + 2d = 8 + 5 = 13$.

Alternatively, one can notice that the 5th term of the sequence is positioned midway between the 3rd term and the 7th term of the arithmetic sequence. Therefore, the 5th term of the sequence is the average (arithmetic mean) of the 3rd term and the 7th term, which is $\frac{8 + 18}{2} = 13$.

Tip

In an arithmetic sequence, the difference between any two consecutive terms is the same. Students should remember that this implies that the difference between the rth term and the sth term is $(s-r)d$, where d is the difference between any two consecutive terms.

3. Correct Answer: C

Explanation: Choice (C) is the correct answer. There are 2 ways to place the black and brown beads on the chain. If the black bead is placed first on the chain, then the brown bead must be placed 7th. If the brown bead is placed first on the chain, then the black bead must be placed 7th.

The other 5 beads must occupy the 2nd through the 6th places, and there are 5 choices for the 2nd place, 4 choices for the 3rd place, 3 choices for the 4th place, 2 choices for the 5th place and one choice for the 6th place. Thus, there are $5 \cdot 4 \cdot 3 \cdot 2 \cdot 1 = 5!$ ways to order the beads in the 2nd through the 6th places on the chain.

Hence, for each of the 2 possible placements of the black and brown beads, there are $5 \cdot 4 \cdot 3 \cdot 2 \cdot 1 = 5!$ ways to order the remaining beads. Altogether, therefore, there are $2 \cdot 5!$ different orderings of the 7 beads on the chain.

ALGEBRA AND FUNCTIONS: EXPRESSIONS, EQUATIONS AND INEQUALITIES

4. **If $(x - 3)(4x + 3) = 0$, and $4x + 3 \neq 0$, then $4x + 3 =$**

A) $-\frac{3}{4}$

B) $-\frac{4}{3}$

C) 3

D) 9

E) 15

5. **$(x + 3)(x + 2)(x - 2) > 0$**

Which of the following is a solution to the inequality above?

A) -4

B) -2

C) -1

D) 0

E) 3

6. **If $\log_b a = 0.6$ and $\log_b c = 0.2$, what is the value of $\log_b(ac)$?**

A) 0.12

B) 0.30

C) 0.40

D) 0.80

E) 3.00

4. Correct Answer: E

Explanation: Choice (E) is the correct answer. Since the product $(x-3)(4x+3)$ is equal to 0, one of the factors $x-3$ or $4x+3$ must be equal to 0. It is given that $4x+3 \neq 0$, and so it must be true that $x-3=0$. Therefore, $x=3$, and so $4x+3=4(3)+3=15$.

Tip

Students should remember that a product is equal to 0 if and only if one of the factors is equal to 0.

5. Correct Answer: E

Explanation: Choice (E) is the correct answer. Substituting 3 for x in the inequality $(x+3)(x+2)(x-2)>0$ yields $(6)(5)(1)>0$, which is a true inequality. Therefore, 3 is a solution to the inequality. It can be checked that the values given in the other options are not solutions of the inequality. This problem can also be solved by graphing $y=(x+3)(x+2)(x-2)$ on a graphing calculator and then trace to find the y– value for each of the given values of x.

Tip

Students should remember that the sign of a product can be found by looking at the signs of its factors.

6. Correct Answer: D

Explanation: Choice (D) is the correct answer. If $\log_b a = 0.6$, then by definition, $b^{0.6}=a$. Similarly, if $\log_b c = 0.2$, then $b^{0.2}=c$. It follows that $ac=b^{0.6}b^{0.2}=b^{0.6+0.2}=b^{0.8}$. Therefore, $\log_b(ac)=0.8$.

Alternatively, directly using properties of logarithms gives $\log_b(ac)=\log_b a+\log_b c=0.6+0.2=0.8$.

ALGEBRA AND FUNCTIONS: REPRESENTATION AND MODELING

7. **If a deer population of 350 increases at the rate of 3 percent per year, what will the population be at the end of 10 years?**

A) 455

B) 470

C) 650

D) 1,400

E) 4,825

8. **For the first *t* hours of a workday, Sean read reports at an average rate of 5 reports per hour. During the rest of the day, he read reports at an average rate of 4 reports per hour. If Sean read a total of 35 reports that day, which of the following represents the number of hours during which he read reports at an average rate of 4 reports per hour?**

A) $\frac{35-5t}{4}$

B) $\frac{35-4t}{5}$

C) $\frac{35t-5}{4}$

D) $\frac{35t-4}{5}$

E) $\frac{5t-4}{35}$

7. **Correct Answer: B**

Explanation: Choice (B) is the correct answer. Since the deer population increases at a rate of 3 percent per year, the population of deer at the end of 1 year will be 350(1.03); at the end of 2 years, $350(1.03)(1.03) = 350(1.03)^2$ and at the end of n years, $350(1.03)^n$. Therefore, at the end of 10 years, the deer population will be $350(1.03)^{10} = 470$.

Tip

Students should remember that the size of a quantity that changes by a fixed percent, rather than a fixed amount, over each time period will be represented by an exponential function.

8. **Correct Answer: A**

Explanation: Choice (A) is the correct answer. Let s be the number of hours during which Sean read reports at an average rate of 4 reports per hour. Since for the first t hours of the workday, he read reports at an average rate of 5 reports per hour, and for the next s hours, he read reports at an average rate of 4 reports per hour, and the total number of reports he read that day was 35, it follows that $5t + 4s = 35$. It follows that $4s = 35 - 5t$, so $s = \frac{35 - 5t}{4}$.

ALGEBRA AND FUNCTIONS: FUNCTIONS AND THEIR PROPERTIES

9. Which of the following functions has zeros at both −1 and 3?

A) $f(x) = \dfrac{x+1}{x-3}$

B) $f(x) = \dfrac{(x+1)(x-3)}{x-3}$

C) $f(x) = \dfrac{(x+1)(x+3)}{x+3}$

D) $f(x) = \dfrac{(x+1)(x-3)}{x+3}$

E) $f(x) = \dfrac{(x-1)(x+3)}{x-3}$

10. If $f(x) = \ln(4x+2)$, what is the value of $f(0.25)$?

A) 0.693

B) 1.099

C) 1.386

D) 1.792

E) 2.079

11. The function $y = f(x)$ is graphed in the xy-plane below. If the period of the function is 6, what is the value of $f(66)$?

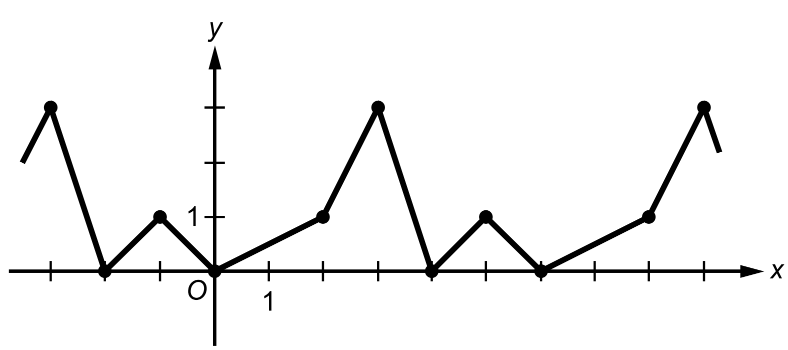
A) 0

B) 0.5

C) 1.5

D) 2

E) 3



9. Correct Answer: D

Explanation: Choice (D) is the correct answer. The functions in choices (A), (B) and (E) have denominator $x - 3$, which is equal to 0 if x is equal to 3. Division by 0 is undefined, so these functions are not defined at 3, and thus cannot have a zero at 3.

The function in choice (C) is defined at both -1 and 3. The function has a zero at -1, because $f(-1) = \frac{(-1+1)(-1+3)}{-1+3} = \frac{(0)(2)}{2} = 0$. However, $f(3) = \frac{(3+1)(3+3)}{3+3} = \frac{(4)(6)}{6} = 4$.
Therefore, this function does not have zeros at both -1 and 3.

For the function in choice (D), $f(-1) = \frac{(-1+1)(-1-3)}{-1+3} = \frac{(0)(-4)}{2} = 0$, and $f(3) = \frac{(3+1)(3-3)}{3+3} = \frac{(4)(0)}{6} = 0$.
Therefore, this function has zeros at both -1 and 3.

10. Correct Answer: B

Explanation: Choice (B) is the correct answer. Since $f(x) = \ln(4x+2)$, it follows that $f(0.25) = \ln(4(0.25)+2) = \ln 3$. Using a calculator, one finds that the value of $\ln 3$ to three decimal places is 1.099.

Tip

Students should remember that if the argument of a function is not a variable, such as x, but an expression in a variable, such as $4x + 2$, then the function is actually a composition of two simpler functions.

11. Correct Answer: A

Explanation: Choice (A) is the correct answer. Since function f is periodic with period 6, it follows that $f(66) = f(0 + 6 \cdot 11) = f(0)$. From the graph, $f(0) = 0$. Therefore, the value of $f(66)$ is 0.

Tip

Students should remember that if a function f is periodic with period p, then for every value x in its domain and any integer n, $f(x) = f(x + np)$.

12.

$$f(x) = 3x - 1$$
$$g(x) = -3x + 1$$

The functions *f* and *g* are defined above. Which of the following must be true for all *x*?

I. $f(-x) = -g(x)$

II. $f(g(x)) = x$

III. $f(x) + g(x) = 0$

A) None
B) I only
C) II only
D) III only
E) I and III

13. In the *xy*-plane, the minimum point of the function *f* defined by $f(x) = x^2 - 4x - 12$ is (r, s). What is the value of *r*?

A) -16
B) -12
C) 2
D) 4
E) 8

14. If $f(x) = \sqrt{x}$ and $g(x) = -3x - 2$, which of the following is NOT in the domain of $f(g(x))$?

A) $-\frac{3}{2}$
B) -1
C) $-\frac{3}{4}$
D) $-\frac{2}{3}$
E) $-\frac{1}{2}$

12. Correct Answer: D

Explanation: Choice (D) is the correct answer. Consider the three statements individually:

Statement I is $f(-x)=-g(x)$, and $f(-x)=3(-x)-1=-3x-1$, and $-g(x)=-(-3x+1)=3x-1$. Since $-3x-1$ and $3x-1$ are equal only if $x=0$, the statement is not true for all x.

Statement II is $f(g(x))=x$, and $f(g(x))=3(-3x+1)-1=-9x+3-1=-9x+2$. Since $-9x+2$ and x are equal only if $x=\frac{1}{5}$, the statement is not true for all x.

Statement III is $f(x)+g(x)=0$, and $f(x)+g(x)=(3x-1)+(-3x+1)=0$. This is true for all values of x.

Therefore, of the three statements, only III is true for all x.

Tip

For questions in Roman numeral format, students should consider each of the three options independently.

13. Correct Answer: C

Explanation: Choice (C) is the correct answer. One can use a graphing calculator with an appropriate window to find that the minimum point of the parabola, which occurs at its vertex, is $(2,-16)$. Thus, the value of r is 2.

Alternatively, since r is the x-coordinate of the parabola's vertex, the value of r is the average of the zeros of $f(x)=x^2-4x-12$. Since $x^2-4x-12=(x+2)(x-6)$, the zeros of $f(x)$ occur at $x=-2$ and $x=6$. Therefore, the value of r is $\frac{-2+6}{2}=2$. Also, if the equation of the parabola is in standard form, $y=ax^2+bx+c$ then the equation of the axis of symmetry is $x=-\frac{b}{2a}$. Since the vertex is on the axis of symmetry, this is the x-coordinate of the vertex.

Tip

Students should remember that, for a parabola with a vertical axis of symmetry and two real zeros, the x-coordinate of its vertex falls midway between its zeros.

14. Correct Answer: E

Explanation: Choice (E) is the correct answer. If $f(x)=\sqrt{x}$ and $g(x)=-3x-2$, then $f(g(x))=f(-3-2)=\sqrt{-3x-2}$. Thus, the domain of $f(g(x))$ consists of all numbers x for which $-3x-2\geq 0$. Solving this inequality for x. gives $x\leq -\frac{2}{3}$. Of the options given, only $-\frac{1}{2}$ is not less than or equal to $-\frac{2}{3}$, and therefore, $-\frac{1}{2}$ is not in the domain of $f(g(x))$.

Tip

Students should remember that the domain of a function $f(x)$ written as $f(x)=\sqrt{a(x)}$, where $a(x)$ is an expression in terms of x, consists of the solution set of the inequality $a(x)\geq 0$.

15. **If $y = \dfrac{3x + 12}{x}$, what value does y approach as x gets infinitely large?**

A) 1
B) 3
C) 12
D) 15
E) y does not approach a single value.

GEOMETRY AND MEASUREMENT: COORDINATE GEOMETRY

16. **In the xy-plane, which of the following is an equation of the line that passes through the point $(-2,3)$ and is perpendicular to the graph of $2x + 5y = 3$?**

A) $y = -\frac{2}{5}x + \frac{11}{5}$
B) $y = -\frac{2}{5}x + \frac{3}{5}$
C) $y = \frac{5}{2}x + \frac{3}{5}$
D) $y = \frac{5}{2}x + 3$
E) $y = \frac{5}{2}x + 8$

15. Correct Answer: B

Explanation: Choice (B) is the correct answer. The equation $y=\frac{3x+12}{x}$ is equivalent to $y=\frac{3x}{x}+\frac{12}{x}=3+\frac{12}{x}$. As x gets infinitely large, the term $\frac{12}{x}$ remains positive but gets smaller and smaller, and so it approaches 0. Therefore, $3+\frac{12}{x}$ approaches 3.

Alternatively, when $y=\frac{3x+12}{x}$ is graphed on a graphing calculator, it is possible to see that as x takes on larger and larger values, the graph approaches a single value. Of the four values given, 3 is the closest to the value that the graph approaches.

Tip

Students should decide when to use their calculators to obtain an answer or as another way to check an answer.

16. Correct Answer: E

Explanation: Choice (E) is the correct answer. The equation $2x+5y=3$ can be rewritten as $y=-\frac{2}{5}x+\frac{3}{5}$, and thus the graph of $2x+5y=3$ is a line with slope $-\frac{2}{5}$. Hence, any line perpendicular to the graph of $2x+5y=3$ has slope equal to $\frac{5}{2}$ (the negative reciprocal of $-\frac{2}{5}$), and so has an equation of the form $y=\frac{5}{2}x+b$. If this line passes through $(-2, 3)$, it follows that $3=\frac{5}{2}(-2)+b$, which gives $b=8$. Therefore, $y=\frac{5}{2}x+8$ is an equation of the line perpendicular to the graph of $2x+5y=3$ that passes through the point $(-2, 3)$.

Tip

Students should remember that perpendicular lines have slopes that are negative reciprocals (except for horizontal and vertical lines).

17. In the xy -plane, points R, S, and T are not collinear. Which of the following describes the set of points that are equidistant from R, S, and T?

A) A single point

B) A line

C) A parabola

D) A circle

E) An ellipse

18. In the xy -plane, which of the following is an equation of the parabola that passes through the points $(-2, 0)$, $(1, 9)$, and $(0, 8)$?

A) $y = (x+2)(x-3)$

B) $y = (x-3)(x-4)$

C) $y = -(x-2)(x+4)$

D) $y = -(x+2)(x+4)$

E) $y = -(x+2)(x-4)$

17. Correct Answer: A

Explanation: Choice (A) is the correct answer. In the xy -plane, the set of all points that are equidistant from R and S lie on the perpendicular bisector of the line segment $\overline{RS}$, and each point on the perpendicular bisector of $\overline{RS}$ is equidistant from R and S. Similarly, the set of all points that are equidistant from T and S lie on the perpendicular bisector of $\overline{TS}$, and each point on the perpendicular bisector of $\overline{TS}$ is equidistant from T and S. Since points R, S, and T are not collinear, the perpendicular bisector of $\overline{RS}$ and the perpendicular bisector of $\overline{TS}$ intersect at a point in the xy -plane. Being on both the perpendicular bisector of $\overline{RS}$ and the perpendicular bisector of $\overline{TS}$, the intersection point of the two bisectors is equidistant from R, S, and T. On the other hand, each point that is equidistant from R, S, and T must be on both perpendicular bisectors. Therefore, the set of points in the xy -plane equidistant from R, S, and T consists of a single point.

Tip

In solving problems involving the locus of points in the plane, students may find it helpful to draw a sketch.

18. Correct Answer: E

Explanation: Choice (E) is the correct answer. The standard form of an equation of a parabola in the xy -plane is $y = ax^2 + bx + c$, where a, b, and c are real numbers. Since the point $(-2, 0)$ is on the parabola, when the equation of the parabola is factored, $x-(-2) = x+2$ must be one of the factors. Of the choices given, (A), (D) and (E) satisfy this condition. Also, since the point $(0, 8)$ is on the parabola, when $x = 0$, the value of y must be 8. Choice (A) does not satisfy this condition because $(0+2)(0-3) = -6 \neq 8$. Choice (D) does not satisfy this condition either because $-(0+2)(0+4) = -8$. However, for the equation in choice (E), $-(0+2)(0-4) = -8$. Finally, it can be confirmed that the point $(1, 9)$ is on the parabola with equation $y = -(x+2)(x-4)$, since $-(1+2)(1-4) = -(3)(-3) = 9$. Therefore, $y = -(x+2)(x-4)$ is an equation of a parabola that passes through the points $(-2, 0)$, $(1, 9)$, and $(0, 8)$.

Tip

It is probably more efficient to do this problem without a calculator, but students may want to use a graphing calculator to confirm their answer.

GEOMETRY AND MEASUREMENT: THREE-DIMENSIONAL GEOMETRY

19. In the figure to the right, O is the center of the base of a right circular cone of height 6. If the area of right triangle OAB is 12, what is the volume of the cone?

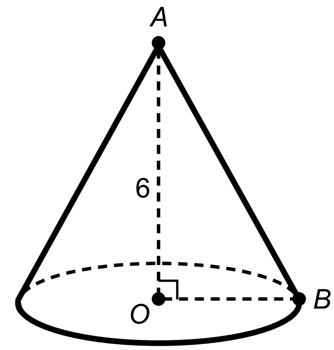
A) 25.13

B) 50.27

C) 75.46

D) 100.53

E) 301.59



Note: Figure not drawn to scale.

GEOMETRY AND MEASUREMENT: TRIGONOMETRY

20. In the figure to the right, B is a point on the ground 50 feet from the base of a tree. The angle of elevation from point B to the top of the tree is $46°$. To the nearest foot, how tall is the tree?

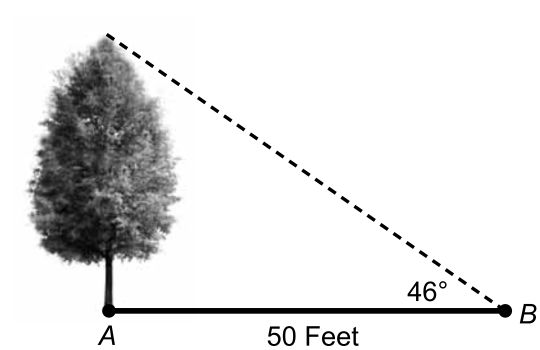
A) 52 feet

B) 49 feet

C) 46 feet

D) 36 feet

E) 35 feet



Note: Figure not drawn to scale.

21. In triangle XYZ, the measure of angle X is $70°$, and the measure of angle Y is $50°$. If the length of side $\overline{YZ}$ is 6, what is the length of side $\overline{XZ}$?

A) 1.81

B) 4.56

C) 4.89

D) 5.53

E) 6.70

Answers and Explanations

19. Correct Answer: D

Explanation: Choice (D) is the correct answer. The area of right triangle OAB is equal to half the product of its legs, $\frac{1}{2}(OA)(OB)$. Since this area is 12, and $OA = 6$ it follows that $OB = 4$. Hence, the cone has height $h = OA = 6$ and base radius $r = OB = 4$. Therefore, the volume of the cone is $\frac{1}{3}\pi r^2 h = \frac{1}{3}(\pi)(4^2)(6) = 100.53$.

Tip

Students should remember that formulas concerning two-dimensional figures can be applied to cross sections of three-dimensional solids. Also, students should know which formulas are given in the reference information at the beginning of the test.

20. Correct Answer: A

Explanation: Choice (A) is the correct answer. From the figure, the height of the tree can be found by multiplying the length of segment $\overline{AB}$ by $\tan(46°)$. Using a calculator, one finds that the height of the tree is $50\tan(46°) \approx 51.7765$ feet. Therefore, 52 feet is the height of the tree to the nearest foot.

21. Correct Answer: C

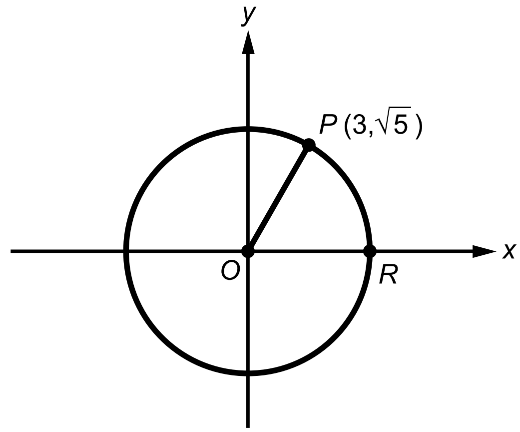
Explanation: Choice (C) is the correct answer. It is given that the measure of angle x is $70°$, the measure of angle Y is $50°$, and the length of side $\overline{YZ}$ is 6. By the law of sines, $\frac{\sin 70°}{YZ} = \frac{\sin 50°}{XZ}$. Solving for XZ, using the calculator, gives $XZ = \frac{(6)(\sin 50°)}{\sin 70°} \approx 4.89$.

Tip

When doing calculations involving the values of trigonometric functions, students should remember to set their calculator in the appropriate mode, either radian or degree measure. Also, they should be aware that intermediate rounding of values may produce an answer that is not sufficiently accurate.

22. In the figure to the right, points P and R are on the circle with center O. What is the degree measure of angle POR?

A) 36.7°
B) 41.8°
C) 48.2°
D) 53.3°
E) 63.7°



Note: Figure not drawn to scale.

DATA ANALYSIS, STATISTICS AND PROBABILITY

23. A consumer advocacy group evaluated 57 products and gave each product a score from 1 to 50, as summarized in the table to the right. Based on this table, which of the following could be the median score for the 57 products?

A) 17
B) 22
C) 26
D) 31
E) 36

Score	Frequency
1–5	3
6–10	8
11–15	9
16–20	9
21–25	12
26–30	3
31–35	5
36–40	2
41–45	5
46–50	1

22. Correct Answer: A

Explanation: Choice (A) is the correct answer. From the figure, the tangent of angle *POR* is equal to

$\frac{\sqrt{5}}{3} = 0.7454$. Using a calculator set in degree mode, one finds $\tan^{-1}(0.7454) = 36.7°$.

Tip

When solving trigonometry problems with a calculator, students should check whether degree mode or radian mode is appropriate for the problem and then be sure their calculator is in the proper mode.

23. Correct Answer: A

Explanation: Choice (A) is the correct answer. If the scores are ordered from the least to the greatest, the median score will be the middle entry in the list. Since there are 57 scores all together, the median will be the 29th entry in the ordered list. Calculating the cumulative frequency for the scores in the table, one sees that the 29th score must be in the 16–20 class interval in the left column of the table. Therefore, of the choices given, only 17 can be the median score.

Tip

Students should remember that the median is the middle value in an ordered data set when the number of data is odd, and the mean of two middle values when the number of data is even.

24. The cafeteria at Evan's school serves seven different main dishes. Evan and his two friends, Michael and Amy, will each choose one of the seven dishes at random. What is the probability that all three friends will choose the same dish?

A) $\frac{1}{6^2}$

B) $\frac{1}{6^3}$

C) $\frac{1}{7}$

D) $\frac{1}{7^2}$

E) $\frac{1}{7^3}$

25. The table to the right gives the temperature, in degrees Fahrenheit, at various cricket chirp rates (number of chirps per second) for the striped ground cricket. Based on a least squares linear regression of the data, what is the predicted temperature when the cricket has 18.0 chirps per second?

A) 82.1° F
B) 84.4° F
C) 86.3° F
D) 87.6° F
E) 89.6° F

TEMPERATURES AT VARIOUS CRICKET CHIRP RATES

Chirps per Second	Temperature (°F)
16.0	71.6
19.8	93.3
17.1	80.6
15.5	75.2
14.7	69.7
15.0	79.6
14.4	76.3
15.4	69.4

24. Correct Answer: D

Explanation: Choice (D) is the correct answer. Once Evan chooses one of the seven dishes, the probability that Michael chooses that same dish at random is $\frac{1}{7}$. If Michael chooses the same dish as Evan, then the probability that Amy also chooses the same dish as Evan and Michael is $\frac{1}{7}$. Therefore, the probability that all three friends choose the same dish is $\left(\frac{1}{7}\right)\left(\frac{1}{7}\right)=\frac{1}{7^2}$.

Note that this is the probability that all three choose the same dish, where the dish has not been specified in advance. The probability that all three will choose a particular dish that has been specified in advance is

$\left(\frac{1}{7}\right)\left(\frac{1}{7}\right)\left(\frac{1}{7}\right)=\frac{1}{7^3}$. However, this is not the question that was asked.

Alternatively, there are $7^3 = 343$ different ways in which Evan, Michael, and Amy can choose their main dish. There are 7 different ways out of 343 that they can all choose the same dish. Therefore, the probability that all three friends choose the same dish is $\frac{7}{343}=\frac{1}{49}=\frac{1}{7^2}$.

Tip

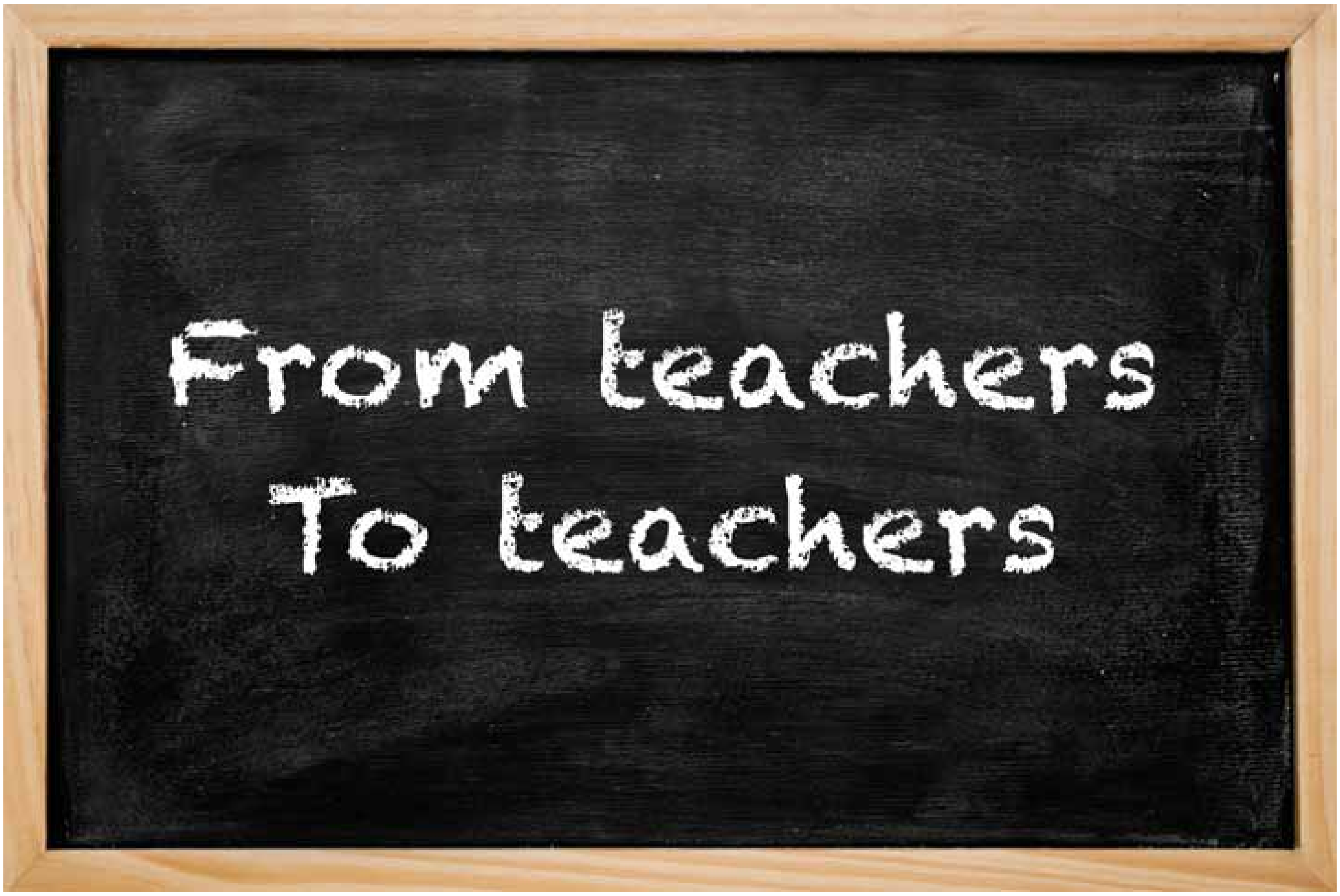
Before computing probabilities of events, students should read carefully to be clear about what the problem is asking.

25. Correct Answer: B

Explanation: Choice (B) is the correct answer. This problem requires the use of a calculator that can compute the equation of a least squares linear regression line, as the computation by hand would be very time-consuming. Enter the rows of the table as ordered pairs (x, y), where x is the number of chirps per second and y is the temperature in degrees Fahrenheit. The least squares regression line of this set of eight ordered pairs (x, y) is $y = 3.69x + 17.97$. Substituting $x = 18.0$ into this equation gives $y = 84.4$. Therefore, based on a least squares linear regression of the given data, when the cricket has 18.0 chirps per second the predicted temperature is $84.4°$ F.

Tip

Students should remember some problems require the use of a calculator.



Best Practices

Student Benefits

Patricia Flad Edmiston, ***Covington High School, Covington, LA***

"The SAT Subject Tests provide students with a method for demonstrating their ability to do well in mathematics, science and other subjects. Students typically take these tests because it helps them get accepted into prestigious universities or aids in obtaining college credit or scholarships."

Dr. Charlotte May, ***St. Michael's Catholic Academy, Austin, TX***

"Students benefit by taking SAT Subject Tests because it fulfills college requirements and helps build self-esteem."

Eliel Gonzalez, ***East Longmeadow High School, East Longmeadow, MA***

"Evidence of solid performance on SAT Subject Tests helps students differentiate themselves from other college applicants in our current extremely competitive admissions process."

Briant McKellips, ***D'Evelyn Jr./Sr. High School, Denver, CO***

"I personally think there is more benefit to taking the SAT Subject Tests than simply college entrance or scholarship benefits. I think the tests provide external validation of our curriculum and aid in students' college readiness skills."

Advising Students

Guy Mauldin, *Science Hill High School, Johnson City, TN*

"I teach honors precalculus and BC Calculus and suggest that all of my students who take the SAT take Math Level 2 Subject Tests."

Patricia Flad Edmiston, *Covington High School, Covington, LA*

"I encourage students who plan to major in a medical field to take SAT Subject Tests, as doing well on the tests can sometimes help them to be admitted to certain premed programs."

Christopher Pesce, *Forest Ridge School of the Sacred Heart, Bellevue, WA*

"I advise all of my honor students to take the Mathematics Level 2 Subject Test, and to make sure that they review the topics that will be covered."

Rodney C. Camden, *E. C. Glass High School, Lynchburg, VA*

"My recommendation for those taking the Mathematics Level 2 Subject Test is to take it in June after the precalculus course and not wait until their senior year."

Dr. Charlotte May, *St. Michael's Catholic Academy, Austin, TX*

"I tell students to take the Math Subject Tests after my Pre-AP precalculus course; they should make sure to review the trigonometry components thoroughly."

Helping Students Prepare

Rodney C. Camden, ***E. C. Glass High School, Lynchburg, VA***

“At the end of each section, my precalculus textbook has practice problems similar to the SAT Subject Test questions, and I assign those as part of their homework.”

Patricia Flad Edmiston, ***Covington High School, Covington, LA***

“I would suggest that all teachers include in both assignments and assessments problems modeled after questions from the tests.”

Kim Schjelderup, ***Mercer Island High School, Mercer Island, WA***

“The three most important things I suggest to students preparing for SAT Subject Tests are:

1. Prepare in advance by practicing the types of questions that may be asked
2. Purchase a practice book
3. Practice, practice, practice”

Eliel Gonzalez, ***East Longmeadow High School, East Longmeadow, MA***

“Schedule your SAT Subject Test to coincide with the end of relevant school work. The time between AP exams and the June administration is a perfect time to prepare for tests with AP connections. Only take the tests that you are prepared for and can do well in.”

Guy Mauldin, ***Science Hill High School, Johnson City, TN***

“Know the material from their courses. I do not advise my students to take prep courses. I am convinced that a good background in their academic preparation is all that they need.”

Dr. Charlotte May, ***St. Michael’s Catholic Academy, Austin, TX***

“Review on your own. Most topics should be covered in the precalculus course. However, familiarity with the format of the test is important. So take sample tests and grade. Ask the teacher if you have problem areas.”

Christopher Pesce, ***Forest Ridge School of the Sacred Heart, Bellevue, WA***

“Get plenty of sleep the night before. Don’t worry or stress out. Do your best, and you’ll be fine.”

CollegeBoard

SAT Subject Tests™

COMPLETE MARK ● EXAMPLES OF INCOMPLETE MARKS

You must use a No. 2 pencil and marks must be complete. Do not use a mechanical pencil. *It is very important that you fill in the entire circle darkly and completely. If you change your response, erase as completely as possible. Incomplete marks or erasures may affect your score.*

1 **Your Name:** (Print) Last First M.I.

I agree to the conditions on the front and back of the SAT Subject Tests™ book. I also agree with the SAT Test Security and Fairness policies and understand that any violation of these policies will result in score cancellation and may result in reporting of certain violations to law enforcement.

Signature: **Today's Date:** / / MM DD YY

Home Address: (Print) Number and Street City State Zip Code

Home Phone: ( ) **Test Center:** (Print) City State/Country

2 YOUR NAME

Last Name (First 6 Letters) | First Name (First 4 Letters) | Mid. Init.

– ' A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

3 DATE OF BIRTH

MONTH | DAY | YEAR

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

0 1 2 3 4 5 6 7 8 9

4 ZIP CODE

0 1 2 3 4 5 6 7 8 9

5 SEX

Female Male

6 REGISTRATION NUMBER

(Copy from Admission Ticket.)

0 1 2 3 4 5 6 7 8 9

7 TEST CENTER

(Supplied by Test Center Supervisor.)

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Important: Fill in items 8 and 9 exactly as shown on the back of test book.

8 BOOK CODE

(Copy and grid as on back of test book.)

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9 BOOK ID

(Copy from back of test book.)

10 TEST BOOK SERIAL NUMBER

(Copy from front of test book.)

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188649-001 1 2 3 4 5 A B C D E Printed in the USA ISD3785

PLEASE DO NOT WRITE IN THIS AREA

SERIAL #

COMPLETE MARK	EXAMPLES OF INCOMPLETE MARKS
●	

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○ Literature	○ Mathematics Level 1	○ German	○ Chinese Listening	○ Japanese Listening
○ Biology E	○ Mathematics Level 2	○ Italian	○ French Listening	○ Korean Listening
○ Biology M	○ U.S. History	○ Latin	○ German Listening	○ Spanish Listening
○ Chemistry	○ World History	○ Modern Hebrew		
○ Physics	○ French	○ Spanish		

Background Questions: ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

1	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	26	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	76	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	27	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	52	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	77	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	28	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	53	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	78	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	29	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	54	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	79	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	30	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	55	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	80	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
6	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	31	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	56	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	81	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	32	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	57	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	82	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	33	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	58	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	83	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	34	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	59	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	84	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
10	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	35	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	60	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	85	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
11	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	36	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	61	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	86	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
12	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	37	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	62	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	87	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
13	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	38	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	63	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	88	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
14	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	39	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	64	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	89	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
15	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	40	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	65	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	90	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
16	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	41	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	66	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	91	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
17	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	42	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	67	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	92	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
18	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	93	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
19	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	44	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	69	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	94	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
20	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	45	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	70	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	95	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
21	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	46	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	71	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	96	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
22	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	47	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	72	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	97	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	48	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	73	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	98	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	49	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	74	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	99	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
25	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	75	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	100	Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

Important: Fill in items 8 and 9 exactly as shown on the back of test book.

8 BOOK CODE (Copy and grid as on back of test book.)

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9 BOOK ID (Copy from back of test book.)

10 TEST BOOK SERIAL NUMBER (Copy from front of test book.)

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4	4	4	4	4	4
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6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

Quality Assurance Mark

Chemistry *Fill in circle CE only if II is correct explanation of I.

	I	II	CE*		I	II	CE*
101	Ⓣ Ⓕ	Ⓣ Ⓕ	○	109	Ⓣ Ⓕ	Ⓣ Ⓕ	○
102	Ⓣ Ⓕ	Ⓣ Ⓕ	○	110	Ⓣ Ⓕ	Ⓣ Ⓕ	○
103	Ⓣ Ⓕ	Ⓣ Ⓕ	○	111	Ⓣ Ⓕ	Ⓣ Ⓕ	○
104	Ⓣ Ⓕ	Ⓣ Ⓕ	○	112	Ⓣ Ⓕ	Ⓣ Ⓕ	○
105	Ⓣ Ⓕ	Ⓣ Ⓕ	○	113	Ⓣ Ⓕ	Ⓣ Ⓕ	○
106	Ⓣ Ⓕ	Ⓣ Ⓕ	○	114	Ⓣ Ⓕ	Ⓣ Ⓕ	○
107	Ⓣ Ⓕ	Ⓣ Ⓕ	○	115	Ⓣ Ⓕ	Ⓣ Ⓕ	○
108	Ⓣ Ⓕ	Ⓣ Ⓕ	○				

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CERTIFICATION STATEMENT

Copy the statement below (do not print) and sign your name as you would an official document.

I hereby agree to the conditions set forth online at sat.collegeboard.com and in any paper registration materials given to me and certify that I am the person whose name and address appear on this answer sheet.

Signature ______________________ Date ______________

By registering, you agreed not to share any specific test question with anyone by any form of communication, including, but not limited to: email, text messages, or use of the Internet. Doing so can result in score cancellation and other possible sanctions.

COMPLETE MARK ●	EXAMPLES OF INCOMPLETE MARKS	***You must use a No. 2 pencil and marks must be complete. Do not use a mechanical pencil.*** *It is very important that you fill in the entire circle darkly and completely. If you change your response, erase as completely as possible. Incomplete marks or erasures may affect your score.*

◯ Literature	◯ Mathematics Level 1	◯ German
◯ Biology E	◯ Mathematics Level 2	◯ Italian
◯ Biology M	◯ U.S. History	◯ Latin
◯ Chemistry	◯ World History	◯ Modern Hebrew
◯ Physics	◯ French	◯ Spanish

Background Questions: ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	26 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	76 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	27 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	52 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	77 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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6 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	31 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	56 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	81 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	32 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	57 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	82 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	33 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	58 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	83 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	34 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	59 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	84 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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15 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	40 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	65 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	90 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
16 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	41 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	66 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	91 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
17 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	42 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	67 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	92 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
18 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	93 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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25 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	75 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	100 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

Quality ● Assurance Mark

Chemistry *Fill in circle CE only if II is correct explanation of I.

	I	II	CE*		I	II	CE*
101	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	109	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
102	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	110	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
103	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	111	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
104	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	112	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
105	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	113	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
106	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	114	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
107	Ⓣ Ⓕ	Ⓣ Ⓕ	◯	115	Ⓣ Ⓕ	Ⓣ Ⓕ	◯
108	Ⓣ Ⓕ	Ⓣ Ⓕ	◯				

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Important: Fill in items 8 and 9 exactly as shown on the back of test book.

8 BOOK CODE

(Copy and grid as on back of test book.)

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9 BOOK ID

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10 TEST BOOK SERIAL NUMBER

(Copy from front of test book.)

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8	8	8	8	8	8
9	9	9	9	9	9

COMPLETE MARK ● EXAMPLES OF INCOMPLETE MARKS

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- ○ Literature
- ○ Biology E
- ○ Biology M
- ○ Chemistry
- ○ Physics
- ○ Mathematics Level 1
- ○ Mathematics Level 2
- ○ U.S. History
- ○ World History
- ○ French
- ○ German
- ○ Italian
- ○ Latin
- ○ Modern Hebrew
- ○ Spanish

Background Questions: ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

1 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	26 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	51 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	76 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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16 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	41 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	66 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	91 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
17 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	42 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	67 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	92 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
18 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	43 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	68 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	93 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
19 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	44 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	69 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	94 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
20 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	45 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	70 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	95 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
21 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	46 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	71 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	96 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
22 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	47 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	72 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	97 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
23 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	48 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	73 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	98 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
24 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	49 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	74 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	99 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
25 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	50 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	75 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	100 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

Important: Fill in items 8 and 9 exactly as shown on the back of test book.

8 BOOK CODE (Copy and grid as on back of test book.)

0	A	0
1	B	1
2	C	2
3	D	3
4	E	4
5	F	5
6	G	6
7	H	7
8	I	8
9	J	9
	K	
	L	
	M	
	N	
	O	
	P	
	Q	
	R	
	S	
	T	
	U	
	V	
	W	
	X	
	Y	
	Z	

9 BOOK ID (Copy from back of test book.)

10 TEST BOOK SERIAL NUMBER (Copy from front of test book.)

0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

Quality ● Assurance Mark

Chemistry *Fill in circle CE only if II is correct explanation of I.

	I	II	CE*		I	II	CE*
101	Ⓣ Ⓕ	Ⓣ Ⓕ	○	109	Ⓣ Ⓕ	Ⓣ Ⓕ	○
102	Ⓣ Ⓕ	Ⓣ Ⓕ	○	110	Ⓣ Ⓕ	Ⓣ Ⓕ	○
103	Ⓣ Ⓕ	Ⓣ Ⓕ	○	111	Ⓣ Ⓕ	Ⓣ Ⓕ	○
104	Ⓣ Ⓕ	Ⓣ Ⓕ	○	112	Ⓣ Ⓕ	Ⓣ Ⓕ	○
105	Ⓣ Ⓕ	Ⓣ Ⓕ	○	113	Ⓣ Ⓕ	Ⓣ Ⓕ	○
106	Ⓣ Ⓕ	Ⓣ Ⓕ	○	114	Ⓣ Ⓕ	Ⓣ Ⓕ	○
107	Ⓣ Ⓕ	Ⓣ Ⓕ	○	115	Ⓣ Ⓕ	Ⓣ Ⓕ	○
108	Ⓣ Ⓕ	Ⓣ Ⓕ	○				

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R/C	W/S1	FS/S2	CS/S3	WS

PLEASE DO NOT WRITE IN THIS AREA

SERIAL #

About the SAT Subject Tests

For more than 75 years, SAT Subject Tests have played an integral role in providing institutions with insights into a student's achievement and readiness for college-level study in specific subject areas. The hour-long exams are offered in five major subject areas: Mathematics, History, Science, Literature and Languages.

SAT Subject Tests are offered six times a year in nearly 7,000 test centers in more than 170 countries. Fee waivers are available for students to take up to six SAT Subject Tests, increasing access for all students.

SAT Subject Tests continue to evolve, maintaining their vital role in the college-going process with new research studies, test and student experience enhancements and updates of student practice tools.

SAT Subject Tests Offered

SAT Subject Tests in nonlanguage subjects assess a student's comprehension of fundamental concepts, their content knowledge and their ability to apply that knowledge to solve routine and nonroutine problems.

SAT Subject Tests in languages assess a student's understanding of the language and ability to communicate in that language in a variety of cultural contexts. When there is a listening component on the test, the skills include reading comprehension, language usage and listening comprehension.

Math Level 1 Math Level 2	U.S. History World History	Biology E/M Chemistry Physics	Literature
Spanish French German	Modern Hebrew Latin Italian	Chinese with Listening Japanese with Listening Korean with Listening	Spanish with Listening French with Listening German with Listening

About the College Board

The College Board is a mission-driven not-for-profit organization that connects students to college success and opportunity. Founded in 1900, the College Board was created to expand access to higher education. Today, the membership association is made up of over 6,000 of the world's leading educational institutions and is dedicated to promoting excellence and equity in education. Each year, the College Board helps more than seven million students prepare for a successful transition to college through programs and services in college readiness and college success—including the SAT® and the Advanced Placement Program®. The organization also serves the education community through research and advocacy on behalf of students, educators and schools. For further information, visit www.collegeboard.org.

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