TABLE A

Answers to the Subject Test in Mathematics Level 2, Form 3YBC, and Percentage of Students Answering Each Question Correctly

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<tr>
<th>Question Number</th>
<th>Correct Answer</th>
<th>Right</th>
<th>Wrong</th>
<th>Percentage of Students Answering the Question Correctly*</th>
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* These percentages are based on an analysis of the answer sheets of a representative sample of 15,855 students who took the original form of this test in May 2002, and whose mean score was 652. They may be used as an indication of the relative difficulty of a particular question. Each percentage may also be used to predict the likelihood that a typical SAT Subject Test in Mathematics Level 2 candidate will answer that question correctly on this edition of the test.
The solutions presented here provide one method for solving each of the problems on this test. Other mathematically correct approaches are possible.

1. Choice (D) is the correct answer. You need to solve the equation $3x+6=\frac{k}{4}(x+2)$ for $k$.

   \[3x+6=\frac{k}{4}(x+2)\]
   \[4(3x+6)=k(x+2)\]
   \[12x+24=k(x+2)\]
   \[12(x+2)=k(x+2)\]
   \[12=k\]

2. Choice (C) is the correct answer. Since $C=\frac{5}{9}(F-32)$, you can substitute for $C$ in the equation $K=C+273$. Thus, $K=\frac{5}{9}(F-32)+273$.

3. Choice (D) is the correct answer. The slope of the line is $\frac{11-5}{3-(-2)}=\frac{6}{5}=1.2$.

4. Choice (A) is the correct answer. One way to find the value of $y$ is to notice that if $x+y=2$ and $y+z=5$, then $x+y+y+z=2+5=7$. Since $x+y+z=10$, you can conclude that $y=7-10=-3$.

5. Choice (C) is the correct answer. $g(5)=e^4$, and $f(e^4)=31e^4-1=31\cdot5-1=14$. Thus, $f(g(5))=14$.

6. Choice (E) is the correct answer. If a plane intersects a cube such that the plane is parallel to a face of the cube, the intersection will be a square, so I is possible. Since a square is a type of parallelogram, II is possible. If a plane intersects a cube so that
it slices through three adjacent faces at a corner of the cube, the intersection will be a triangle, so III is possible. Since I, II, and III are all possible.

7.

Choice (C) is the correct answer. It is helpful to draw a figure with the information given in the problem. The distance between A and B is $x + y$, so you need to find $x$ and $y$. Since $\tan 84.1^\circ = \frac{12}{x}$, $x = \frac{12}{\tan 84.1^\circ}$, which is approximately 1.24. Since $\tan 62.7^\circ = \frac{12}{y}$, $y = \frac{12}{\tan 62.7^\circ}$, which is approximately 6.19. Thus, $AB = x + y = 1.24 + 6.19 = 7.43\text{ km}$.

Choice (A) is incorrect. $0.97 \neq \frac{\tan 84.1^\circ}{12} + \frac{\tan 62.7^\circ}{12}$. Choice (D) is incorrect. This results from using incorrect ratios.

$$\sin 84.1^\circ = \frac{x}{12}$$
$$\sin 62.7^\circ = \frac{y}{12}$$
$$x = 12 \sin 84.1^\circ$$
$$y = 12 \sin 62.7^\circ$$

$$AB = x + y = 12 \sin 84.1^\circ + 12 \sin 62.7^\circ \approx 22.60$$

Choice (B) is incorrect. This results from using incorrect ratios.

$$\tan 84.1^\circ = \frac{x}{12}$$
$$\tan 62.7^\circ = \frac{y}{12}$$
$$x = 12 \tan 84.1^\circ$$
$$y = 12 \tan 62.7^\circ$$

$$AB = x + y = 12 \tan 84.1^\circ + 12 \tan 62.7^\circ \approx 139.37$$

8. Choice (D) is the correct answer. If $x = \sqrt{15^2 - 12^2}$, then $x^2 = 15^2 - 12^2$, which is equal to $225 - 144 = 81$. 

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9. Choice (D) is the correct answer. The distance $d$ from the origin to point $P(x, y)$ is equal to $\sqrt{x^2+y^2}$. The distance from the origin to point $P'(2x, 2y)$ is equal to $\sqrt{4x^2+4y^2} = \sqrt{4(x^2+y^2)} = 2\sqrt{x^2+y^2}$, which is $2d$.

10. Choice (B) is the correct answer. You are looking for the input value that gives an output value of $\frac{2\sqrt{x^2+1} - 1}{\sqrt{x^2+1} + 1}$. In this case, $f(\sqrt{x^2+1}) = \frac{2\sqrt{x^2+1} - 1}{\sqrt{x^2+1} + 1}$. Thus, $g(x) = \sqrt{x^2+1}$.

11. Choice (E) is the correct answer. Since $\sin A = \cos(90^\circ - A)$, it follows that if $\sin A = 0.8$, then $\cos(90^\circ - A)$ is also equal to 0.8.

12. Choice (C) is the correct answer. $x^2 + y^2 + z^2 = r^2$ is the standard form for the equation of a sphere with center $(0, 0, 0)$ and radius $r$. Thus, $x^2 + y^2 + z^2 = 1$ is a sphere with center $(0, 0, 0)$ and radius 1.

13. Choice (B) is the correct answer. The graph of $f$ has vertical asymptotes at $x$ values for which $f(x)$ is undefined. This occurs when the denominator equals 0. Since $x^2 - 8x + 16 = (x - 4)^2 = 0$ when $x = 4$, the graph has a vertical asymptote at $x = 4$ only. Choice (A) is incorrect. Since $f(0)$ is defined, $x = 0$ is not a vertical asymptote. The graph of $f$ has a horizontal asymptote at $y = 0$. Choice (C) is incorrect. The numerator does not give information about vertical asymptotes. Since $f(5)$ is defined, $x = 5$ is not a vertical asymptote.

14. Choice (D) is the correct answer. To answer this question, it is helpful to realize that finding $c$ in the equation is equivalent to finding the $y$-intercept of the graph, since $y = c$ when $x = 0$. From the figure shown, the graph appears to intersect the $y$-axis near $-80$. Only $-72$ is near $-80$. Since $(-6, 0)$ is a point on the graph, you can verify that $-72$ is correct by substituting $-6$ for $x$ in the equation $(-6)^4 + 10(-6)^3 + 10(-6)^2 - 96(-6) - 72 = 0$.

15. Choice (A) is the correct answer. Since the secant of an angle is the reciprocal of the cosine, $\sec x = \frac{1}{\cos x} = \frac{1}{0.4697} = 2.1290$. 

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16. Choice (B) is the correct answer. The question asks for the cost for each club member to go on the trip. Each club member must pay the admission price of $7. The \( n \) club members must share the $200 cost of the bus, so each member must pay \( \frac{200}{n} \) dollars. In addition, the \( n \) club members must share the $14 for admission for the 2 chaperones. So each member must pay a total of \( 7 + \frac{200}{n} + \frac{14}{n} \) dollars. This is equal to \( 7 + \frac{214}{n} \) or \( 7 + \frac{214}{n} \) dollars. Choice (A) is incorrect. This answer does not include the $14 for admission for the 2 chaperones. Each member must pay \( \frac{14}{n} \) dollars of that amount.

17. Choice (B) is the correct answer. For any point \((x, y)\) on the graph, the distance between \((x, y)\) and \((0, 0)\) should equal the distance between \((x, y)\) and \((0, 4)\). That is, \(\sqrt{x^2 + y^2} = \sqrt{x^2 + (y-4)^2}\). Solving the equation gives \(y = 2\). Both of the given points lie on the \(y\)-axis. The set of points equidistant from these points is a horizontal line that goes through \((0, 2)\). The equation of this line is \(y = 2\).

18. Choice (A) is the correct answer. The sum \(S\) of an infinite geometric series is given by \(S = \frac{a}{1-r}\), where \(a\) is the first term and \(r\) is the common ratio. In this series, \(a = \frac{1}{4}\) and \(r = \frac{1}{2}\). Thus, the sum is \(\frac{1}{4} - \frac{1}{2} = \frac{1}{2}\). Choice (D) is incorrect. This results from \(\frac{1}{1 - \frac{1}{2}} = 2\) (forgetting to include the first term) or from thinking that \(\frac{1}{2} = \frac{1}{2}\).

19. Choice (D) is the correct answer. The inequality \(p + s > p - s\) is equivalent to \(s > -s\), which is equivalent to \(2s > 0\). So, \(s > 0\).

20. Choice (D) is the correct answer. Since \(a\) and \(b\) are in the domain of the function \(f\) and \(f(a) < f(b)\), it must be true that \(f(a) \neq f(b)\). This implies that \(a \neq b\). Note that \(a\) could be less than \(b\) if, for example, the function is increasing, and \(a\) could be greater than \(b\) if the function is decreasing.
21. Choice (C) is the correct answer. You need to recognize that the probability you seek corresponds to a compound event, since the person must live within 10 miles of the largest city and live in a single-family house. If \( P \) represents the entire state's population, then \( 0.75P \) residents live within 10 miles of the largest city. Of the \( 0.75P \) residents, 40% live in single-family houses. This is equal to \( (0.40)(0.75P) = (0.30)P \). This tells you that 30% of the state's population live in single-family houses within 10 miles of the largest city. This means that the desired probability is 0.30. Choice (A) is incorrect. This results from taking 40% of the 25% of the population that do not live within ten miles of the largest city \((0.40 \times 0.25)\). Choice (B) is incorrect. This is equal to \( 0.60 \times 0.25 \). Choice (D) is incorrect. This is equal to \( 0.75 - 0.40 \).

22. Choice (C) is the correct answer. In the right triangle, the length of the hypotenuse is 5, and the length of the side opposite the smallest angle \( A \) in the triangle is 3. Thus, \( \sin A = \frac{3}{5} \) and \( \sin^{-1}\left(\frac{3}{5}\right) \approx 36.87^\circ \). The measure of the smallest angle in the right triangle rounded to the nearest degree is 37°.

23. Choice (C) is the correct answer. The product of the slopes of two perpendicular lines is \(-1\). Since the line \( y = -2x + 3 \) has a slope of \(-2\), a line perpendicular to that line has a slope of \(\frac{1}{2} \). Among the choices, only choice (C) gives the equation of a line that has a slope of \(\frac{1}{2} \).

24. Choice (B) is the correct answer. The range of the function \( f \) depends on the range of \( \sin(2x + 5\pi) \). Since \(-1 \leq \sin(2x + 5\pi) \leq 1\), \(-3 \leq 3\sin(2x + 5\pi) \leq 3\) and \(-7 \leq -4 + 3\sin(2x + 5\pi) \leq -1\).

25. Choice (E) is the correct answer. The standard deviation of three numbers will be smallest for the numbers that are closest to each other. In choice (E), the three numbers all have the same value, so their standard deviation is 0. If all three numbers are not identical, then the standard deviation of the numbers, regardless of how small the numbers are, will always be greater than 0.
26. Choice (D) is the correct answer. According to the formula, \(5,000 = 1,000e^{0.08t}\), which is equivalent to \(5 = e^{0.08t}\). Taking the natural logarithm of both sides of the equation gives \(\ln 5 = 0.08t\). Thus, \(t = \frac{\ln 5}{0.08} \approx 20.1\).

27. Choice (B) is the correct answer. Since \(\sin \theta > 0\), the product \(\sin \theta \cos \theta\) will be negative only when \(\cos \theta\) is negative. Since \(\sin \theta\) is positive in the first and second quadrants, and \(\cos \theta\) is negative in the second and third quadrants, \(\theta\) must be in the second quadrant. Choice (A) is incorrect. In quadrant 1, the second inequality fails. Choice (C) is incorrect. In quadrant III, \(\sin \theta < 0\), so the first inequality fails.

28. Choice (C) is the correct answer. The graph of the function \(f\) is the set of points \((x, f(x))\). Since \((3, 8)\) is on the graph, \(f(3) = 8\). Since \(f(-x) = f(x), f(-3) = f(3) = 8\). This means that the point \((-3, 8)\) is also on the graph of \(f\).

29. Choice (E) is the correct answer. It is given that if \(x = y\), then \(x^2 = y^2\). You need to examine each choice to see if it can or cannot be inferred. Choice (A) can be inferred. If \(x = y\), we know that \(x^2\) must be equal to \(y^2\) from the given statement. Choice (B) can be inferred. If \(x^2 \neq y^2\), then it must be true that \(x \neq y\). Choice (C) can be inferred. This is another way to state that if \(x = y\), then \(x^2 = y^2\). Choice (D) can be inferred. If \(x^2 \neq y^2\), then it is not possible for \(x\) to equal \(y\). Choice (E) cannot be inferred. If \(x^2 = y^2\), then \(x = y\) or \(x = -y\).

30. Choice (D) is the correct answer. There are 9 choices for the first position, 8 choices for the second position, and so on. So, nine students can arrange themselves in a straight line in \(9 \cdot 8 \cdot 7 \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2 \cdot 1\) ways. The product is \(9! = 362,880\).

31. Choice (C) is the correct answer. By using a graphing calculator, one can see that the value of the function \(\frac{\ln x}{x - 1}\) approaches 1 as \(x\) approaches 1 from both sides. You can examine the graph of the function or a table of values for the function as \(x\) approaches 1 from both sides. Thus, \(\lim_{x \to 1} \frac{\ln x}{x - 1} = 1\).

32. Choice (D) is the correct answer. \(f(2) = |5 - 3 \cdot 2| = |1| = 1\). Since \(|-1| = |1|\), \(f(x) = |1|\) when \(5 - 3x = 1\) or when \(x = \frac{4}{3}\). Thus, \(f(2) = f\left(\frac{4}{3}\right)\).
33. Choice (D) is the correct answer. The period of the graph of \( y = 2 \tan(3\pi x + 4) \) is the same as the period of the graph of \( y = \tan(3\pi x) \). Since the period of the graph of \( y = \tan x \) is \( \pi \), the period of the graph of \( y = \tan(3\pi x) \) is \( \left( \frac{1}{3\pi} \right) \pi = \frac{1}{3} \).

34. Choice (C) is the correct answer. Let \( n \) represent the distance the truck travels along North Road. Then \( n^2 + 20^2 = 50^2 \), so \( n = \sqrt{2100} \) miles. Thus, the total distance traveled by the truck from point B to point A is \( \sqrt{2100} + 20 \) miles. The time it takes the truck to get to the car is equal to \( \frac{\sqrt{2100} + 20}{45 \text{ miles/hour}} \) miles/hour = 1.46 hours. The 0.46 hours is converted to minutes by multiplying 0.46 by 60, which gives 27.6 or 28 minutes. Choice (A) is incorrect. This is equal to the time it takes to travel from the intersection to A along East Road. Choice (B) is incorrect. This is equal to the time it takes to drive from B to A directly instead of along North and East Roads. Choice (D) is incorrect. This is obtained by adding the two given values, 50 miles and 20 miles, and computing the time to travel 70 miles. Choice (E) is incorrect. It takes the truck 1.46 hours to get to the car, and 0.46 hour is not the same as 46 minutes.

35. Choice (B) is the correct answer. Since \( f(-1) = 0 \), \( (x+1) \) is a factor of \( f(x) \). Similarly, since \( f(2) = 0 \), \( (x-2) \) is a factor of \( f(x) \). This means that \( f(x) \) can be written as \( f(x) = (x+1)(x-2)(x-a) \) for some real number \( a \). Using \( f(0) = 1 \) gives \( (0+1)(0-2)(0-a) = 1 \), which simplifies to \( a = \frac{1}{2} \). Similarly, using \( f(1) = -1 \) gives \( (1+1)(1-2)(1-a) = -1 \), which also simplifies to \( a = \frac{1}{2} \). Thus, \( f(x) \) could be equal to \( f(x) = (x+1)(x-2)(x-\frac{1}{2}) \).

36. Choice (D) is the correct answer. Since the only prime factors of the number \( n \) are 2, 5, 7, and 17, the only prime factors of any factor of \( n \) are 2, 5, 7, and 17. Hence the numbers 10 = 2 \times 5, 20 = 2^2 \times 5, 25 = 5^2, and 34 = 2 \times 17 are all possible factors of \( n \), but 30 = 2 \times 3 \times 5 could not be a factor of \( n \), since 3 is not one of the prime factors of \( n \).

37. Choice (E) is the correct answer. The equation \( \sin x = 3 \cos x \) can be rewritten as \( \tan x = 3 \), when \( x \neq \frac{\pi}{2} \). Solving for \( x \) yields \( x = \tan^{-1}(3) \approx 1.249 \).
38. Choice (C) is the correct answer. To find \( f^{-1}(10) \), you need to find the value of \( x \) for which 10 = \( 5\sqrt{2x} \). This equation simplifies to 2 = \( \sqrt{2x} \) and so \( x = 2 \).

39. Choice (C) is the correct answer. In the sequence, \( a_n \) is equal to the sum of the previous two terms for \( n \geq 3 \). Thus, the first ten terms of the sequence are 1, 1, 2, 3, 5, 8, 13, 21, 34, 55. Since \( a_{10} = 55 \). Choice (A) is incorrect. This is \( a_8 \). Choice (B) is incorrect. This is \( a_7 \). Choice (D) is incorrect. This is \( a_{11} = a_{10} + a_7 = 89 \). Choice (E) is incorrect. This is \( a_{12} = a_{11} + a_9 = 144 \).

40. Choice (D) is the correct answer. Use a graphing calculator to draw the graph of the function \( f \). The graph shows that \( f \) has three \( x \)-intercepts; therefore, the equation \( f(x) = 0 \) has three real solutions. Thus, statement II is false. The graph also shows that \( f \) has just two turning points: a local maximum at the point \( \left( -\frac{1}{3}, \frac{68}{27} \right) \) and a local minimum at the point \( (3, -16) \). Thus, \( f \) is increasing for \( x \geq 3 \) and \( f(x) \geq -16 \) for all \( x \geq 0 \). Statements I and III are true.

41. Choice (A) is the correct answer. For \( x > 0 \), \( f(x) > 0 \) and \( g(x) < 0 \), so \( (fg)(x) = f(x)g(x) < 0 \). For \( x < 0 \), \( f(x) < 0 \) and \( g(x) > 0 \), so \( (fg)(x) = f(x)g(x) < 0 \). Thus, \( (fg)(x) < 0 \) for all nonzero \( x \) shown and \( (fg)(0) = f(0)g(0) = 0 \cdot 0 = 0 \). Moreover, since \( |(fg)(x)| \) increases as \( |x| \) increases, \( fg \) is increasing for \( x < 0 \) and decreasing for \( x > 0 \).

42. Choice (B) is the correct answer. Every positive number \( n \) has two square roots, one positive and the other negative, but \( \sqrt{n} \) denotes the positive number whose square is \( n \). The square root of 0 is 0. In this case, this means that \( \sqrt{x^2} \geq 0 \), therefore \( -x \) must be nonnegative and \( x \) must be nonpositive. Hence, the set of all real numbers \( x \) such that \( \sqrt{x^2} = -x \) consists of nonpositive real numbers only.

43. Choice (C) is the correct answer. Using the law of sines, \( \frac{4}{\sin \alpha} = \frac{3}{\sin 30^\circ} \). Since \( \sin 30^\circ = \frac{1}{2} \) this becomes \( \frac{4}{\sin \alpha} = 6 \). Hence, \( \sin \alpha = \frac{4}{6} = \frac{2}{3} \).
44. Choice (B) is the correct answer. To answer this question, it is helpful to draw a figure. The longest line segment shown in the figure is the segment between the points labeled A and B. $\overline{AB}$ is the hypotenuse of a right triangle in which one leg is the height of the rectangular solid and the second leg is the diagonal of the face with sides of length 4 and 8. By the Pythagorean theorem, the length of $\overline{AB}$ is $\sqrt{1^2 + (\sqrt{4^2 + 8^2})^2} = \sqrt{1 + (\sqrt{80})^2} = \sqrt{81} = 9$. Choice (A) is incorrect. This is the length of the longest diagonal of any face of the solid. However, a segment joining opposite vertices is longer than a diagonal of a face.

45. Choice (A) is the correct answer.

Since $\log_a 45 = \log_a (9 \cdot 5) = \log_a 9 + \log_a 5 = \log_a 3^2 + \log_a 5 = 2 \log_a 3 + \log_a 5 = 2x + y$.

46. Choice (B) is the correct answer. Since $\sin^2 \theta + \cos^2 \theta = 1$, $\cos^2 \theta = 1 - \sin^2 \theta$. Thus, $\cos^2 \theta = 1 - t^2$, since $\sin \theta = t$; and $\cos \theta = \sqrt{1 - t^2}$, since $0 < \theta < \frac{\pi}{2}$. Hence, $\tan \theta = \frac{\sin \theta}{\cos \theta} = \frac{t}{\sqrt{1 - t^2}}$.

47. Choice (E) is the correct answer. Completing the square yields $y = (x^2 - 2x + 1) - 1 + k = (x-1)^2 + (k-1)$. Hence, shifting the graph of $y = x^2$ right 1 unit and up $k-1$ units would result in the graph of $y = x^2 - 2x + k$.

48. Choice (A) is the correct answer. You can solve this problem by comparing the volumes of the original and new cones. If you use $h$ and $r$ for the height and radius, respectively, of the original cone, its volume is $V = \frac{1}{3} \pi r^2 h$. In the new cone, the height is $0.92h$ and the volume is $0.85V$. You need to determine the percent decrease in the radius, so you could represent the new radius length by $kr$, where $0 < k < 1$ and $(1-k)(100)$ is the percent you are looking for. This gives you the volume of the
new cone as \( 0.85V = \frac{1}{3} \pi (kr)^2 (0.92h) \). By using \( V = \frac{1}{3} \pi r^2 h \), we have \( 0.85 \left( \frac{1}{3} \pi r^2 h \right) = \frac{1}{3} \pi (kr)^2 (0.92h) \). If you divide each side by common terms, you get \( 0.85 = k^2 \cdot (0.92) \) so that \( k^2 \approx 0.9239 \) or \( k \approx 0.9612 \). The percent decrease in the radius is \( 100(1-k) \), so the correct answer is 4%. Choice (C) is incorrect. If \( V \) is the volume of the original cone, the volume of the new cone is equal to \( 0.85V = \frac{1}{3} \pi (kr)^2 (0.92h) \). If you use \( k \) instead of \( k^2 \), your answer will be 8%.

49. Choice (D) is the correct answer. For two matrices \( M \) and \( N \), the product \( MN \) exists provided the number of columns of \( M \) equals the number of rows of \( N \). The product \( MN \) has as many rows as \( M \) and as many columns as \( N \). Since matrix \( B \) has \( p \) columns and matrix \( A \) has \( m \) rows, the product \( BA \) does not exist, so statement I is true. Since \( A \) has \( n \) columns and \( B \) has \( n \) rows, the product \( AB \) exists and has as many rows as \( A \), which is \( m \) rows, and as many columns as \( B \), which is \( p \) columns. Thus, statement II is true and statement III is false.

50. Choice (A) is the correct answer. The complex number \( w \) is equal to \( a + bi \), where \( a < 0 \) and \( b > 0 \). Multiplying by \(-i\) will give \(-ai - bi^2 = b - ai\). Thus, \( b > 0 \) and \(-a > 0\). So \(-iw\) is in quadrant I. The \( x \)-coordinate of \(-iw\) equals \( b \), and the \( y \)-coordinate equals \(-a\). Choice (C) is incorrect. It results from not recognizing that \( a \) was originally negative and thus \(-a\) is positive, which will give a point in quadrant IV. Choice (D) is incorrect. This corresponds to omitting the minus sign, and concluding that the point \( iw \) is in quadrant III. Choices (B) and (E) are incorrect. They both result from ignoring the \( a \) term in \( a + bi \). This would mean that \( w = bi \), so multiplying by \( i \) would produce a complex number with only a real part.