# Form B02
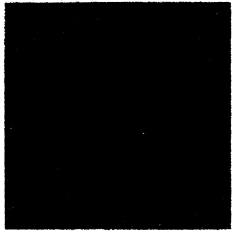
## (June 2019)

M|S

# The ACT® 2018|2019

In response to your request for Test Information Release materials, this booklet contains the test questions, scoring keys, and conversion tables used in determining your ACT scores. Enclosed with this booklet is a report that lists each of your answers, shows whether your answer was correct, and, if your answer was not correct, gives the correct answer.

If you wish to order a photocopy of your answer document—including, if you took the writing test, a copy of your written essay—please use the order form on the inside back cover of this booklet.

*011292190*

## MATHEMATICS TEST

*60 Minutes—60 Questions*

**DIRECTIONS:** Solve each problem, choose the correct answer, and then fill in the corresponding oval on your answer document.

Do not linger over problems that take too much time. Solve as many as you can; then return to the others in the time you have left for this test.

You are permitted to use a calculator on this test. You may use your calculator for any problems you choose, but some of the problems may best be done without using a calculator.

Note: Unless otherwise stated, all of the following should be assumed.

1. Illustrative figures are NOT necessarily drawn to scale.
2. Geometric figures lie in a plane.
3. The word *line* indicates a straight line.
4. The word *average* indicates arithmetic mean.

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1. A calculator has a regular price of $59.95 before taxes. It goes on sale at 20% below the regular price. Before taxes are added, what is the sale price of the calculator?

   A. $11.99
   B. $29.98
   C. $39.95
   D. $47.96
   E. $54.95

2. Given $r = 6$, $b = 4$, and $g = -9$, $(r + b - g)(b + g) = ?$

   F. −95
   G. −5
   H. 5
   J. 13
   K. 14

3. In the figure below, $C$ is on $\overline{BD}$, $\angle BAC$ measures 42°, and $\angle ABC$ measures 108°. What is the measure of $\angle ACD$ ?

   A. 108°
   B. 120°
   C. 132°
   D. 138°
   E. 150°
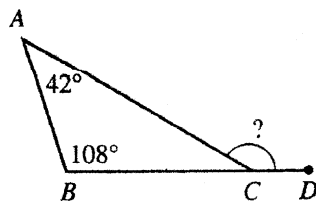
   

4. If $\frac{3}{5}x + 10 = 17$, then $x = ?$

   F. $-\frac{35}{3}$

   G. $\frac{5}{3}$

   H. $\frac{35}{3}$

   J. $\frac{21}{5}$

   K. 45

**DO YOUR FIGURING HERE.**

**DO YOUR FIGURING HERE.**

5. What is the length, in inches, of the hypotenuse of a right triangle with a leg that is 9 inches long and a leg that is 2 inches long?

A. $\sqrt{22}$

B. $\sqrt{77}$

C. $\sqrt{85}$

D.    5.5

E.    11

6. A bag contains exactly 18 solid-colored buttons: 3 red, 5 blue, and 10 white. What is the probability of randomly selecting 1 button that is NOT white?

F. $\frac{1}{18}$

G. $\frac{1}{8}$

H. $\frac{4}{9}$

J. $\frac{2}{3}$

K. $\frac{4}{5}$

7. What is the sum of 3 consecutive odd integers whose mean is 27 ?

A. 39

B. 75

C. 81

D. 87

E. 93

8. Two dials are shown below. When the arrow on each dial is spun, it is equally likely to point at any of the numbered sectors on its dial after it has stopped spinning. After the arrows are next spun, the numbers in the sectors the arrows point at after they stop spinning will be added together. Which of the following values is NOT a possible sum of those 2 numbers?



F. 1

G. 4

H. 6

J. 7

K. 8
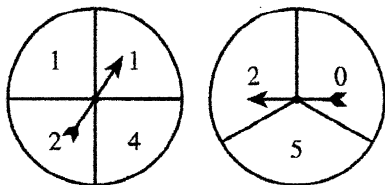
**9.** On a bike trail there are 5 checkpoints numbered in order, Checkpoint 1 through Checkpoint 5, as shown in the figure below. Some distances along the trail between 2 checkpoints are given: 6.6 miles between 1 and 3; 4.5 miles between 2 and 3; and 9.7 miles between 2 and 5. Which of the following values is closest to the distance, in miles, along the trail between Checkpoint 1 and Checkpoint 5 ?

A. 11.1
B. 11.8
C. 14.2
D. 16.3
E. 20.8
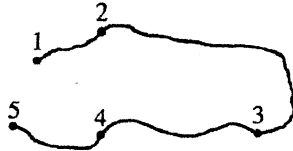
**10.** In the figure below, a circle with a radius of 10 meters circumscribes a regular hexagon. What is the perimeter, in meters, of the hexagon?

F. 30
G. $30\sqrt{3}$
H. 60
J. $60\sqrt{2}$
K. $60\sqrt{3}$
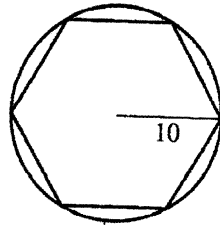
**11.** To produce aluminum softball bats, it costs the Recreation Equipment Supply Company $3,500 for overhead, plus $2 per softball bat produced. What is the maximum number of bats that can be produced by the company for $15,000 ?

A. 1,750
B. 3,502
C. 5,000
D. 5,750
E. 7,500

**12.** Given that $3x + 2 = 4$ and $2y + 6 = 5$, what is $x + y$ ?

F. $-\frac{1}{2}$

G. $\frac{1}{6}$

H. $\frac{2}{3}$

J. $\frac{7}{6}$

K. $\frac{15}{2}$

**13.** For all $x$ such that $x \neq 0$, which of the following expressions is equivalent to $\frac{15x^2 + 25x}{5x}$ ?

A. $8x$
B. $28x$
C. $3x + 5$
D. $3x^2 + 5$
E. $15x^2 + 5$

**14.** What is the value of the expression $\dfrac{|-3-2|^2+(-1)^3}{16 \div 4 \times 2 - 5}$ ?

   F.   $-8$

   G.   $-\dfrac{2}{3}$

   H.   $\dfrac{2}{3}$

   J.   $\dfrac{26}{3}$

   K.   $8$

**15.** Karen invested $2,000 in a special savings account. The balance of this special savings account will double every 5 years. Assuming that Karen makes no other deposits and no withdrawals, what will be the balance of Karen's investment at the end of 40 years?
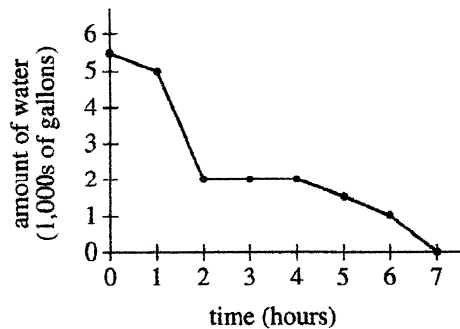
   A.   $    80,000
   B.   $   256,000
   C.   $   400,000
   D.   $   512,000
   E.   $1,024,000

**16.** The graph below shows the amount of water in a pond over a period of 7 hours. One of the following values is the number of hours the amount of water in the pond remained constant. Which one?



   F.   2
   G.   3
   H.   3.5
   J.   4
   K.   7

**17.** If it rains in Franklin City on a particular day, the probability that it will rain there the following day is 0.70. If it does not rain in Franklin City on a particular day, the probability that it will rain there the following day is 0.10. Given that it rained in Franklin City on Monday, what is the probability that it will NOT rain in Franklin City on Tuesday of the same week?

   A.   0.10
   B.   0.30
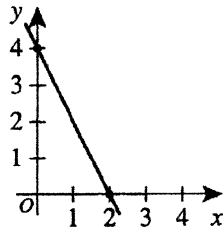   C.   0.60
   D.   0.70
   E.   0.90

**18.** In the standard $(x,y)$ coordinate plane, what is the slope of the line given by the equation $5x = 9y + 18$ ?

**F.** $-\dfrac{5}{9}$

**G.** $\dfrac{5}{9}$

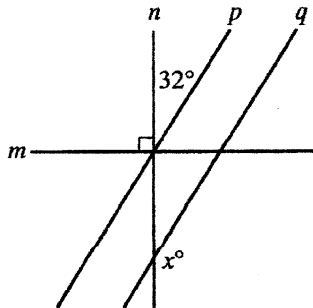**H.** $\dfrac{9}{5}$

**J.** $5$

**K.** $9$

**19.** One of the following equations represents the line graphed in the standard $(x,y)$ coordinate plane below. Which one?



**A.** $y = -2x + 2$
**B.** $y = -2x + 4$
**C.** $y = 2x + 4$
**D.** $y = 4x - 2$
**E.** $y = 4x + 2$

**20.** In the figure below, line $m$ is perpendicular to line $n$, and line $p$ is parallel to line $q$. Lines $m$, $n$, and $p$ intersect at a single point. Some angle measures are given. What is the value of $x$ ?



**F.** 32
**G.** 58
**H.** 122
**J.** 148
**K.** 158

**21.** A bag contains 10 solid-colored marbles of the same size: 3 red, 2 green, 1 yellow, and 4 blue. Which of the following expressions gives the probability of drawing, at random and without replacement, a blue marble on the 1st draw, a green marble on the 2nd draw, and a blue marble on the 3rd draw?

**A.** $\left(\dfrac{4}{10}\right)\left(\dfrac{2}{10}\right)\left(\dfrac{3}{10}\right)$

**B.** $\left(\dfrac{4}{10}\right)\left(\dfrac{2}{10}\right)\left(\dfrac{4}{10}\right)$

**C.** $\left(\dfrac{4}{10}\right)\left(\dfrac{2}{9}\right)\left(\dfrac{4}{8}\right)$

**D.** $\left(\dfrac{4}{10}\right)\left(\dfrac{2}{9}\right)\left(\dfrac{3}{8}\right)$

**E.** $\left(\dfrac{4}{10}\right)\left(\dfrac{3}{9}\right)\left(\dfrac{3}{8}\right)$

**DO YOUR FIGURING HERE.**

**DO YOUR FIGURING HERE.**

22. A physical education teacher recorded the distances, in inches, that her students jumped during a long jump lesson. The distances of 1 jump by each of the students are represented in the stem-and-leaf plot below.

| Stem | Leaf |
|---|---|
| 3 | 7 8 |
| 4 | 3 5 6 7 |
| 5 | 2 4 5 8 9 |
| 6 | 0 1 2 3 6 |
| 7 | 0 1 2 |

Key: 5 | 2 = 52 inches

What is the probability that a student chosen at random from the class will have jumped *at least* 60 inches?

F.  $\frac{5}{24}$

G.  $\frac{8}{24}$

H.  $\frac{5}{19}$

J.  $\frac{7}{19}$

K.  $\frac{8}{19}$

23. Given that the function $f$ defined as $f(x) = 5 - 3x$ has domain $\{-1, 0, 2\}$, what is the range of $f$?

A.  $\{-2, 0, \ 4\}$
B.  $\{-1, 2, \ 8\}$
C.  $\{-1, 5, \ 8\}$
D.  $\{ \ 2, 5, \ 8\}$
E.  $\{ \ 2, 5, 11\}$

24. To the nearest 1 foot, what is the height of a rectangular prism with a base length of 15 feet, a base width of $1\frac{1}{3}$ feet, and a volume of 100 cubic feet?

F.  5
G.  7
H.  9
J.  20
K.  75

**25.** Tables of values for the 2 functions $f$ and $g$ are shown below. What is the value of $g(f(5))$ ?

| $x$ | $f(x)$ | | $x$ | $g(x)$ |
|-----|--------|---|-----|--------|
| −7  | 9      | | −3  | 5      |
| −3  | −7     | | 1   | −1     |
| 1   | 5      | | 3   | −5     |
| 5   | 3      | | 5   | −7     |

A. −21
B. −7
C. −5
D. 3
E. 9

**DO YOUR FIGURING HERE.**

**26.** In the figure shown below, a ladder 15 feet long forms an angle of 56° with the level ground as it leans against the vertical side of a building. The distance along the building, in feet, between the ground and the top of the ladder is equal to which of the following expressions?

F. $\dfrac{15}{2}$

G. $\dfrac{15\sqrt{3}}{2}$

H. $15 \sin 56°$

J. $15 \cos 56°$

K. $15 \tan 56°$
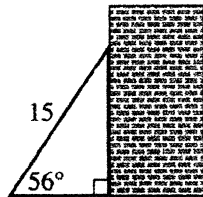
**27.** The isotope iodine-131 has a half-life of 8 days, which means that the amount of iodine-131 remaining after $t$ days is $N\left(\dfrac{1}{2}\right)^{\frac{t}{8}}$, where $N$ is the number of grams of iodine-131 at $t = 0$. How many grams of iodine-131 will remain after 16 days if there were 32 grams of iodine-131 at $t = 0$ ?

A. 0
B. 2
C. 8
D. 16
E. 128

**28.** Which of the following expressions is equivalent to $\sqrt[4]{256x^{16}}$ ?

F. $4x^4$
G. $4x^{12}$
H. $16x^4$
J. $64x^{12}$
K. $128x^8$

**29.** Two concentric circles have radii of 5 centimeters and 6 centimeters, respectively. How many centimeters longer is the circumference of the larger circle than that of the smaller circle?

A. 1
B. $\pi$
C. $2\pi$
D. $11\pi$
E. $22\pi$

**30.** Squares with sides of length $x$ cm have been removed from each corner of a rectangle measuring 8 cm by 18 cm, resulting in the figure shown below. In terms of $x$, what is the area, in square centimeters, of the figure?
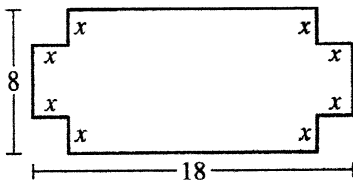


F. $52 - 4x^2$
G. $144 - 4x^2$
H. $144 + 4x^2$
J. $144 - 8x$
K. $144 - 52x + 4x^2$

**31.** In the standard $(x,y)$ coordinate plane below, $\triangle ABC$ will be translated 10 units down and then the resulting image will be reflected over the $y$-axis. What will be the coordinates of the final image of $A$ resulting from both transformations?
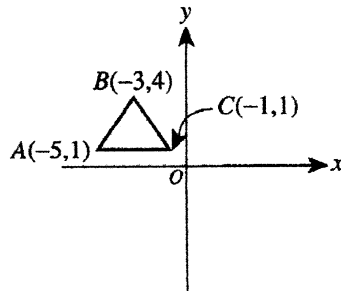


A. $(-5, \ 9)$
B. $(-1, \ 9)$
C. $(\ 1, -9)$
D. $(\ 5, -10)$
E. $(\ 5, -9)$

**32.** Olivia, Ashton, and Jane are standing on a soccer field such that Olivia is 20 meters due west of Ashton and Jane is 40 meters due north of Ashton. Their positions are at the vertices of a triangle. Which of the following expressions gives the degree measure of the angle of the triangle at the vertex where Olivia is standing?
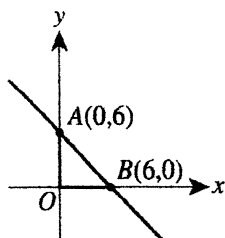
F. $\cos^{-1}\left(\dfrac{40}{20}\right)$

G. $\sin^{-1}\left(\dfrac{40}{20}\right)$

H. $\sin^{-1}\left(\dfrac{20}{40}\right)$

J. $\tan^{-1}\left(\dfrac{40}{20}\right)$

K. $\tan^{-1}\left(\dfrac{20}{40}\right)$

**DO YOUR FIGURING HERE.**

Use the following information to answer questions 33–35.

In the standard $(x,y)$ coordinate plane below, $\triangle AOB$ is formed by $\overleftrightarrow{AB}$, the $x$-axis, and the $y$-axis.



**33.** What is the area of $\triangle AOB$ in square coordinate units?

A.  6
B.  $6\sqrt{2}$
C.  12
D.  18
E.  36

**34.** What is the length of $\overline{AB}$ in coordinate units?

F.  $2\sqrt{6}$
G.  $6\sqrt{2}$
H.  $6\sqrt{3}$
J.  6
K.  12

**35.** Which of the following is an equation of $\overleftrightarrow{AB}$ ?

A.  $y = -x + 6$
B.  $y = x - 6$
C.  $y = x + 6$
D.  $y = -6x - 6$
E.  $y = 6x + 6$

**36.** Which of the following arranges the numbers $\frac{9}{5}$, $1.\overline{8}$, $1.08$, and $1.\overline{08}$ into ascending order? (Note: The overbar notation shows that the digits under the bar will repeat. For example, $1.\overline{73} = 1.737373...$)

F.  $\frac{9}{5} < 1.\overline{08} < 1.08 < 1.\overline{8}$

G.  $\frac{9}{5} < 1.08 < 1.\overline{08} < 1.\overline{8}$

H.  $1.\overline{08} < 1.08 < \frac{9}{5} < 1.\overline{8}$

J.  $1.08 < 1.\overline{08} < 1.\overline{8} < \frac{9}{5}$

K.  $1.08 < 1.\overline{08} < \frac{9}{5} < 1.\overline{8}$

**DO YOUR FIGURING HERE.**

**37.** Andre's Floral Shop asked each of 20 customers to give a rating of the shop's service. The table below summarizes the 20 customer ratings.

| Rating | Number of customers |
|--------|---------------------|
| 3 | 6 |
| 2 | 8 |
| 1 | 2 |
| 0 | 4 |

Which of the following values is closest to the mean of the 20 customer ratings?

A. 1.8
B. 2.0
C. 2.3
D. 2.7
E. 3.3

**38.** Which of the following operations will produce the largest result when substituted for the blank in the expression $14 \underline{\hspace{1cm}} \left(-\frac{1}{40}\right)$ ?

F. Plus
G. Minus
H. Divided by
J. Multiplied by
K. Averaged with

**39.** A local bowling league established its handicap for bowlers who have an average of 200 or less as 75% of the difference between 200 and the bowler's average score. If $H$ represents the handicap of such a bowler and $A$ represents his or her average score, which of the following equations gives $H$ in terms of $A$ ?

A. $H = 150 - A$

B. $H = A - 150$

C. $H = 200 - \dfrac{A}{0.75}$

D. $H = 200 - 0.75A$

E. $H = 0.75(200 - A)$

**40.** The equation $t = -0.0066a + 15$ models the noon temperature, $t$ degrees Celsius, $a$ meters above sea level, on a certain day on Laurel Mountain. According to this equation, what would be the noon temperature for that certain day on Laurel Mountain at sea level?
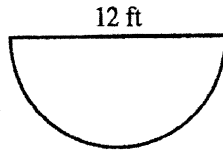
F. 0°C
G. 0.0066°C
H. 14.9934°C
J. 15°C
K. 15.0066°C

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**41.** The semicircular top surface of Ron's patio is shown below. Which of the following values is closest to the area, in square feet, of the top surface of the patio?

A. 18
B. 36
C. 54
D. 108
E. 186

12 ft

**42.** Which of the following equations is that of a circle that is in the standard $(x,y)$ coordinate plane, has center $(1,-4)$, and has a radius of 5 coordinate units?

F.  $(x-1)+(y+4)=5$
G.  $(x+1)+(y-4)=5$
H.  $(x-1)^2+(y+4)^2=\sqrt{5}$
J.  $(x-1)^2+(y+4)^2=25$
K.  $(x+1)^2+(y-4)^2=25$

**43.** What is the smallest positive integer having exactly 5 different positive integer divisors?

A.  5
B.  6
C.  12
D.  16
E.  18

**44.** If $49^a = 7$ and $3^{a+b} = 81$, then $b = ?$

F.  $\dfrac{1}{2}$

G.  $\dfrac{3}{2}$

H.  $\dfrac{5}{2}$

J.  3

K.  $\dfrac{7}{2}$

**45.** Florencia has 60 feet of fencing and a 4-foot-wide gate to use to enclose a dog pen. Among the following, a dog pen of which shape and dimensions will have the largest area if only the fencing and the gate are used to enclose it?

A.  A square with a side length of 16 feet
B.  A square with a side length of 17 feet
C.  A rectangle with a length of 14 feet and a width of 16 feet
D.  A rectangle with a length of 15 feet and a width of 17 feet
E.  A rectangle with a length of 15 feet and a width of 18 feet

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**46.** The difference $\frac{3}{5} - \frac{-1}{3}$ lies in which of the following intervals graphed on the real number line?

**DO YOUR FIGURING HERE.**

F. 

$\frac{1}{5}$  $\frac{2}{5}$  $\frac{3}{5}$  $\frac{4}{5}$  1

G.

$\frac{1}{5}$  $\frac{2}{5}$  $\frac{3}{5}$  $\frac{4}{5}$  1

H.

$\frac{1}{5}$  $\frac{2}{5}$  $\frac{3}{5}$  $\frac{4}{5}$  1

J.

$\frac{1}{5}$  $\frac{2}{5}$  $\frac{3}{5}$  $\frac{4}{5}$  1

K.

$\frac{1}{5}$  $\frac{2}{5}$  $\frac{3}{5}$  $\frac{4}{5}$  1
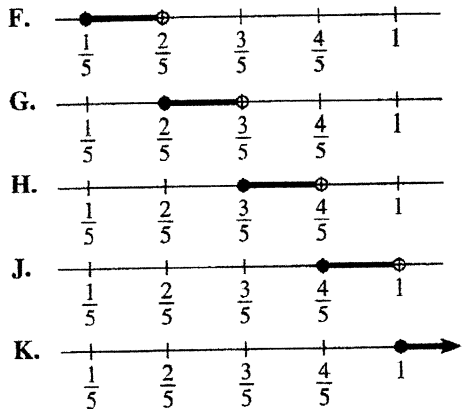
**47.** The recursive formula for a sequence is given below, where $a_n$ is the value of the $n$th term.

$$a_1 = 10$$
$$a_n = a_{n-1} + 5$$

Which of the following equations is an explicit formula for this sequence?

A. $a_n = -5n + 10$
B. $a_n = 5n + 5$
C. $a_n = 5n + 10$
D. $a_n = 10n - 5$
E. $a_n = 10n + 5$

**48.** The probabilities that each of 2 independent events will occur are given in the table below.

| Event | Probability |
|-------|-------------|
| A | 0.20 |
| B | 0.40 |

What is the probability that both Events A and B will occur—that is, P(A and B) ?

F. 0.08
G. 0.20
H. 0.30
J. 0.50
K. 0.60

**49.** What is the solution set of the equation $x^4 + 21x^2 - 100 = 0$ ?

A. $\{-25, 4\}$
B. $\{-25, -2, 2\}$
C. $\{-5, -4, 5\}$
D. $\{-5, 5, -2i, 2i\}$
E. $\{-2, 2, -5i, 5i\}$

> Use the following information to answer questions 50–52.

Skyline Tours is offering hot-air-balloon tours. The tables below give information about the balloon, the equipment, and the tours offered.

| Hot-air-balloon information | |
|---|---|
| Volume of balloon | 80,000 cubic feet |
| Maximum capacity of basket | 8 people |
| Weight of balloon | 200 pounds |
| Weight of basket | 150 pounds |
| Weight of burner | 50 pounds |

| Tour information | | | |
|---|---|---|---|
| Tour | Ticket price | Duration, in minutes | Maximum altitude, in feet |
| A | $100 | 45 | 500 |
| B | $125 | 60 | 600 |
| C | $200 | 90 | 1,000 |

50. Jarrod is looking up at a hot-air balloon. The balloon is currently at the maximum altitude during Tour C. The angle of elevation from the horizon is 37°, as shown in the figure below. Which of the following expressions is closest to the distance, $d$ feet, from Jarrod to the basket?

   F. $\dfrac{1,000}{\sin 37°}$

   G. $\dfrac{1,000}{\cos 37°}$

   H. $1,000 \sin 37°$

   J. $1,000 \cos 37°$

   K. $1,000 \tan 37°$
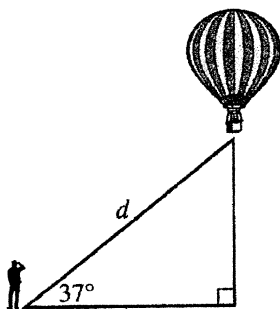


51. Skyline Tours made $5,000 in 1 day by selling a total of 30 tickets for Tours A, B, and C. They sold twice as many tickets for Tour B as for Tour A. How many tickets were sold for Tour C ?

   A.   4
   B.   8
   C.  12
   D.  16
   E.  18

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**52.** Jarrod went on Tour A, and his trip covered a distance of 6 miles. Bhumi went on Tour C, and her trip covered a distance of 9 miles. Which of the following values is the difference, in miles per hour, of the average speeds of their balloons during their tours?

   **F.** 0
   **G.** 2
   **H.** 3
   **J.** 8
   **K.** 9

**53.** A forest fire is contained within a triangular region, which is shown below. The supervising firefighter plans to fight the fire by positioning a firefighter about every 4 meters along the perimeter of the triangle. Among the following, which expression best estimates the planned number of firefighters along the perimeter?

(Note: The law of sines states that in every triangle, the 3 ratios of length of a side to the sine of the angle opposite that side are equal.)



130 meters
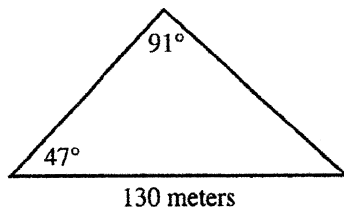
   **A.** $\dfrac{130 + \left(\frac{130 \sin 42°}{\sin 91°}\right) + \left(\frac{130 \sin 47°}{\sin 91°}\right)}{4}$

   **B.** $\dfrac{130 + \left(\frac{130 \sin 91°}{\sin 42°}\right) + \left(\frac{130 \sin 91°}{\sin 47°}\right)}{4}$

   **C.** $130 + \dfrac{130 \sin 42°}{\sin 91°} + \dfrac{130 \sin 47°}{\sin 91°}$

   **D.** $\dfrac{\frac{1}{2}\left(\frac{130 \sin 47°}{\sin 91°}\right)}{4}$

   **E.** $\dfrac{\frac{1}{2}(130)}{4}$

**54.** How many integers between, but not including, 20 and 30 have a prime factorization with exactly 3 factors that are NOT necessarily unique?

(Note: 1 is NOT a prime number.)

   **F.** 1
   **G.** 2
   **H.** 3
   **J.** 4
   **K.** 5

55. The graphs of $y = -x + 1$, $y = x - 3$, and $x^2 + y^2 = 9$ are shown in the standard $(x,y)$ coordinate plane below. The shaded region is the solution set to one of the following systems of inequalities. Which system is it?
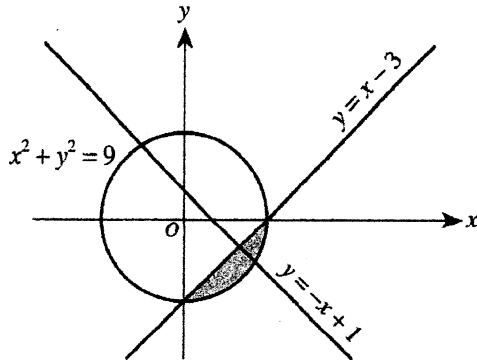
A. $y \le x - 3$
   $x^2 + y^2 \le 9$

B. $y \le x - 3$
   $x^2 + y^2 \ge 9$

C. $y \le -x + 1$
   $x^2 + y^2 \le 9$

D. $y \ge x - 3$
   $x^2 + y^2 \le 9$

E. $y \ge -x + 1$
   $x^2 + y^2 \ge 9$

56. The function $f(x)$ is shown below with several points labeled. Another function, $g(x)$, is defined such that $g(x) = -[f(x) - 3]$. What is $g(4)$ ?
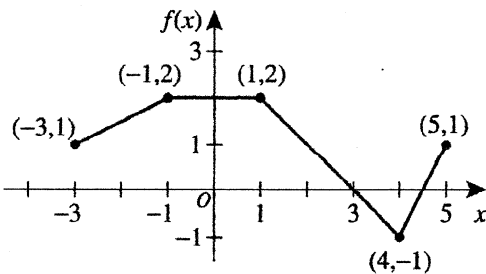


F. $-4$
G. $-1$
H. $1$
J. $4$
K. $7$

57. The ratio of $a$ to $b$ is 6 to 1, and the ratio of $b$ to $c$ is 12 to 1. What is the value of $\frac{2a + 3b}{4b + 3c}$ ?

A. $\frac{3}{8}$

B. $\frac{5}{17}$

C. $\frac{16}{17}$

D. $\frac{60}{17}$

E. $\frac{48}{7}$

**58.** The frequency histogram below shows the distribution of the heights, in inches, of 11 basketball players.

heights of the basketball players
(inches)
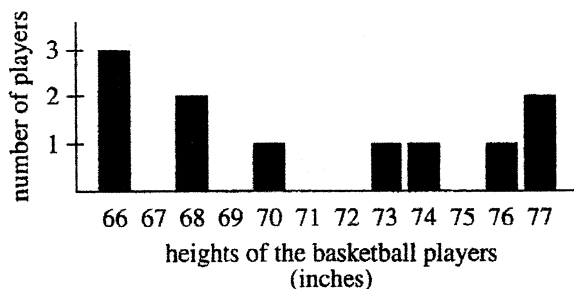
Using the data from the frequency histogram, what is the sum of the mean and the median of this distribution?

F. 141
G. 142
H. 143
J. 144
K. 145

**59.** In the standard $(x,y)$ coordinate plane, what is the $y$-intercept of the graph of the function $y = f(x)$ defined below?

$$f(x) = \begin{cases} x^2 - 1 & \text{for } x < -3 \\ 2x - 5 & \text{for } -3 \le x \le 2 \\ |x - 3| & \text{for } x > 2 \end{cases}$$

A. −5
B. −3
C. −1
D. 2.5
E. 3

**60.** What is the matrix product $\begin{bmatrix} 2 & 4 \\ 6 & 5 \end{bmatrix} \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ ?

F. $\begin{bmatrix} 2a & 4b \\ 6c & 5d \end{bmatrix}$

G. $\begin{bmatrix} (2a + 4b) \\ (6c + 5d) \end{bmatrix}$

H. $\begin{bmatrix} (2a + 6c) & (4b + 5d) \end{bmatrix}$

J. $\begin{bmatrix} (2a + 6b) & (4a + 5b) \\ (2c + 6d) & (4c + 5d) \end{bmatrix}$

K. $\begin{bmatrix} (2a + 4c) & (2b + 4d) \\ (6a + 5c) & (6b + 5d) \end{bmatrix}$

**END OF TEST 2**

**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**

**DO NOT RETURN TO THE PREVIOUS TEST.**

## SCIENCE TEST
### *35 Minutes—40 Questions*

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

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

___

### Passage I

As an apple ripens, it undergoes changes in its *firmness* (the maximum force that can be applied to the apple without puncturing its skin) and in its production of *volatile* (readily vaporized) compounds. A study examined how the storage time at 1°C affected the firmness and the *volatile abundance* (the concentration of volatile compounds produced) of 4 different varieties of apples. Table 1 shows how the average firmness of each variety changed over time at 1°C. Table 2 shows how the average volatile abundance of each variety changed over time at 1°C. (Note: All the apples were of identical maturity at 0 days.)

| Table 1 | | | | |
|---|---|---|---|---|
| Variety of apple | Average firmness (in N*) of apples stored at 1°C for: | | | |
| | 0 days | 60 days | 120 days | 180 days |
| Fuji | 73 | 70 | 58 | 56 |
| Gala | 76 | 59 | 51 | 46 |
| Granny Smith | 72 | 63 | 49 | 45 |
| Red Delicious | 78 | 62 | 52 | 50 |
| *newtons | | | | |

| Table 2 | | | | |
|---|---|---|---|---|
| Variety of apple | Average volatile abundance (in mg/L*) of apples stored at 1°C for: | | | |
| | 0 days | 60 days | 120 days | 180 days |
| Fuji | 4.4 | 6.1 | 8.2 | 9.3 |
| Gala | 5.5 | 9.8 | 7.7 | 4.0 |
| Granny Smith | 1.0 | 1.2 | 2.4 | 3.3 |
| Red Delicious | 2.7 | 9.1 | 8.8 | 8.6 |

*milligrams of volatile compounds per liter of air at 1 atmosphere of pressure

1. Suppose that a grocery store wants to purchase a variety of apple that will retain as much of its initial firmness as possible when stored at 1°C for 6 months. Based on Table 1, which of the 4 varieties tested would best meet the store's selection criterion?
   A. Fuji
   B. Gala
   C. Granny Smith
   D. Red Delicious

2. According to Table 2, in the study, was the initial average volatile abundance of the Red Delicious apples greater than 2.0 mg/L, less than 2.0 mg/L, or equal to 2.0 mg/L ?
   F. Greater
   G. Less
   H. Equal
   J. Cannot be determined from the given information

3. A student predicted that as the duration of storage at 1°C increased from 0 days through 180 days, the average concentration of volatile compounds produced by the apples would always increase. According to Table 2, this prediction was consistent with the data for which of the 4 varieties of apples?
   A. Granny Smith only
   B. Red Delicious only
   C. Fuji and Granny Smith only
   D. Fuji, Gala, Granny Smith, and Red Delicious

4. Based on Table 2, which of the following graphs best shows the average volatile abundances of the 4 varieties of apples at a storage time of 60 days?

F.



G.



H.



J.
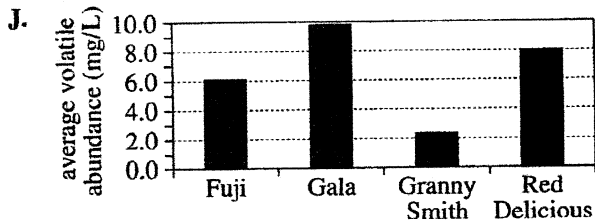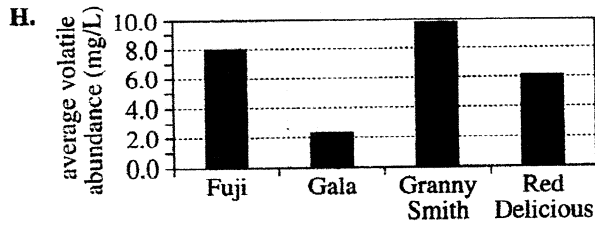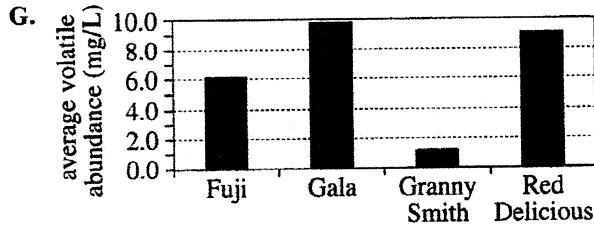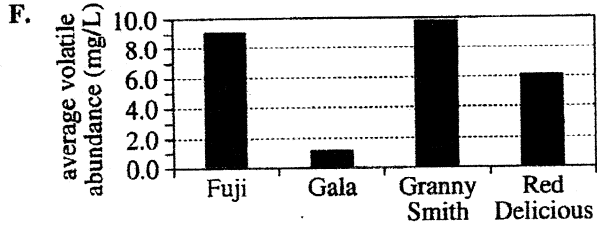


5. Based on Table 1, which of the 4 varieties of apples showed the greatest change in average firmness between 60 days of storage and 120 days of storage?

   A. Fuji
   B. Gala
   C. Granny Smith
   D. Red Delicious

6. Consider the statement "Among the 4 varieties of apples tested, the variety that initially had the least average firmness was also the variety that had the greatest average volatile abundance at a storage time of 180 days." Do the data in Tables 1 and 2 support this statement?

   F. Yes; that variety was Fuji.
   G. Yes; that variety was Granny Smith.
   H. No; on average, the Fuji apples initially had the least firmness, but the Granny Smith apples had the greatest volatile abundance at 180 days.
   J. No; on average, the Granny Smith apples initially had the least firmness, but the Fuji apples had the greatest volatile abundance at 180 days.

## Passage II

*Mass movement* is the movement of soil or rock down a slope. Two types of mass movement are *soil creep* and *block glide* (see Figure 1).



soil creep
(Material at or close to surface
moves faster than deeper material.)



block glide
(Entire block of material moves
at approximately the same speed.)
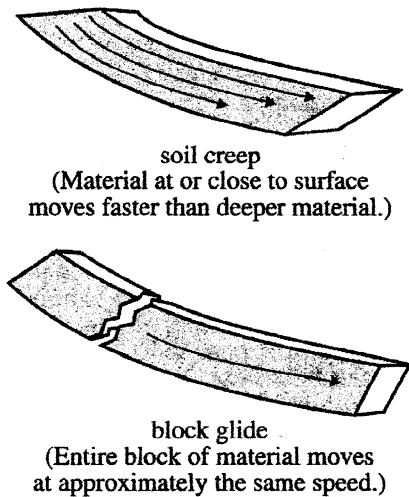
Figure 1

Scientists studied soil creep at 3 sites (Sites 1–3) and block glide at 3 other sites (Sites 4–6) in a particular region. Beginning on March 1, 1995, and every 6 months thereafter until September 1, 1998, the scientists measured the cumulative distance that material at the surface had moved since September 1, 1994. Figures 2 and 3 show the results for Sites 1–3 and for Sites 4–6, respectively. Each figure also shows the amount of precipitation that fell at each of the 3 sites over each 6-month period.
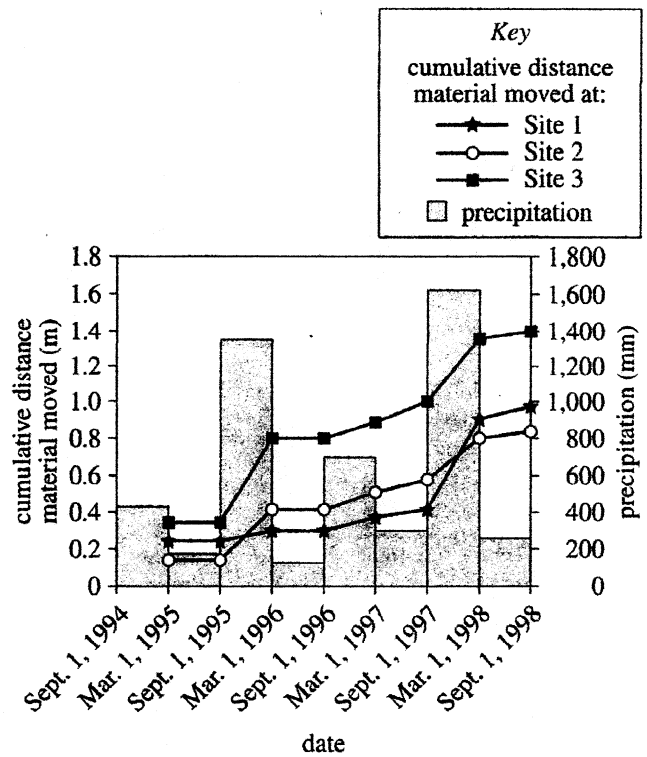


Figure 2
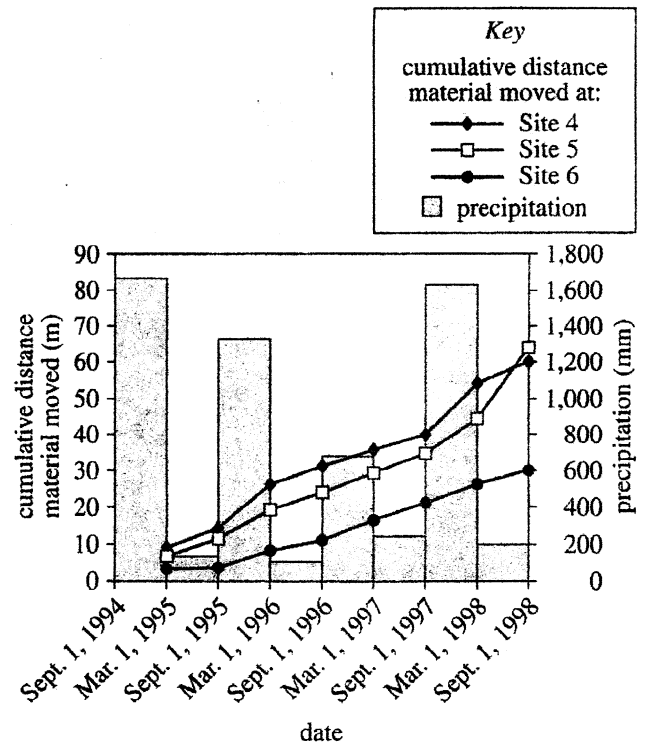


Figure 3

Figures 2 and 3 adapted from D. N. Swanston, R. R. Ziemer, and R. J. Janda, "Rate and Mechanics of Progressive Hillslope Failure in the Redwood Creek Basin, Northwestern California." U.S. Geological Survey Professional Paper 1454-E, 1995.

7. According to Figure 3, the distance that material moved at Site 5 was greatest between which of the following dates?

 A. March 1, 1995, and September 1, 1995
 B. March 1, 1996, and September 1, 1996
 C. March 1, 1997, and September 1, 1997
 D. March 1, 1998, and September 1, 1998

8. Which of the following statements best explains why precipitation data were collected along with cumulative distance data?

 F. Water that runs off the surface may decrease the rate of mass movement.
 G. Water that runs off the surface may stop mass movement.
 H. Water that infiltrates the soil or rock may increase the rate of mass movement.
 J. Water that infiltrates the soil or rock may stop mass movement.

9. According to Figure 3, which of the following graphs best shows the cumulative distance that material moved at Sites 4-6 by March 1, 1996 ?
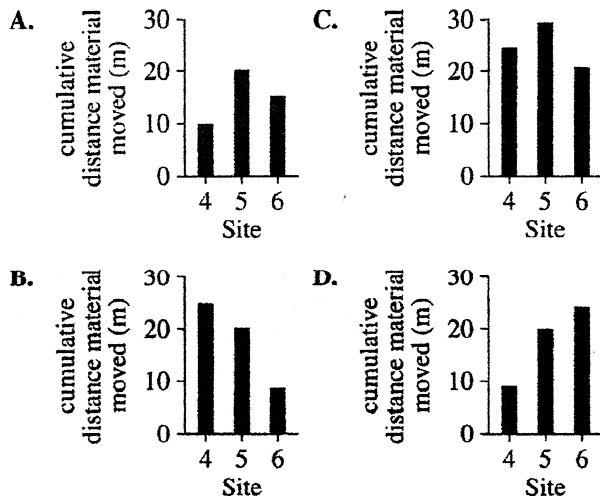


10. Consider in Figure 2 the 6-month periods during which there was no soil creep at any of Sites 1-3. During those periods, the amount of precipitation that fell at each of the sites was:

 F. less than 250 mm.
 G. between 250 mm and 275 mm.
 H. between 275 mm and 300 mm.
 J. greater than 300 mm.

11. Suppose that at Site 2 the scientists had also measured, every 6 months, the cumulative distance that material at a depth of 2 m below the surface had moved since September 1, 1994. Based on Figures 1 and 2, on March 1, 1998, would they have more likely measured a cumulative distance of less than 0.8 m or greater than 0.8 m ?

 A. Less than 0.8 m, because material at a depth of 2 m below the surface moved faster than material at the surface.
 B. Less than 0.8 m, because material at a depth of 2 m below the surface moved slower than material at the surface.
 C. Greater than 0.8 m, because material at a depth of 2 m below the surface moved faster than material at the surface.
 D. Greater than 0.8 m, because material at a depth of 2 m below the surface moved slower than material at the surface.

12. According to Figures 2 and 3, over the study period, was the cumulative distance that material moved due to soil creep less than or greater than the cumulative distance that material moved due to block glide?

 F. Less; material moved as much as 0.8 m due to soil creep, whereas material moved as much as 30 m due to block glide.
 G. Less; material moved as much as 1.4 m due to soil creep, whereas material moved as much as 64 m due to block glide.
 H. Greater; material moved as much as 30 m due to soil creep, whereas material moved as much as 0.8 m due to block glide.
 J. Greater; material moved as much as 64 m due to soil creep, whereas material moved as much as 1.4 m due to block glide.

**Passage III**

Students performed 3 experiments to investigate the absorption of $H_2O$ by dried *chickpeas* (a type of bean).

*Experiment 1*

A sample of 50 dried chickpeas with similar sizes and masses was selected. The total mass of the sample was measured, and the *average initial mass per chickpea* ($CM_i$) was calculated. The sample was immersed in 200 mL of distilled $H_2O$ at 20°C. After 20 min, 5 chickpeas were removed from the distilled $H_2O$ and gently patted dry with a paper towel, and their total mass was then measured. The *average final mass per chickpea* ($CM_f$) was calculated. At each of 6 different times thereafter, another 5 chickpeas were removed from the distilled $H_2O$ and gently patted dry with a paper towel, and their $CM_f$ was determined. The *average moisture uptake per chickpea* (CMU) was then calculated for each group of 5 chickpeas using the following equation:

$$CMU = \frac{CM_f - CM_i}{CM_i}$$

The results are shown in Table 1.

| Table 1 | |
|---|---|
| Soaking time (min) | CMU |
| 20 | 0.15 |
| 40 | 0.25 |
| 60 | 0.31 |
| 90 | 0.40 |
| 120 | 0.47 |
| 180 | 0.57 |
| 270 | 0.68 |

*Experiment 2*

The students repeated the procedure from Experiment 1 at 4 other temperatures (see Table 2).

| Table 2 | | | | |
|---|---|---|---|---|
| Soaking time (min) | CMU at a temperature (in °C) of: | | | |
| | 5 | 30 | 40 | 50 |
| 20 | 0.10 | 0.19 | 0.23 | 0.28 |
| 40 | 0.19 | 0.32 | 0.38 | 0.43 |
| 60 | 0.23 | 0.40 | 0.47 | 0.57 |
| 90 | 0.31 | 0.50 | 0.58 | 0.70 |
| 120 | 0.36 | 0.57 | 0.69 | 0.79 |
| 180 | 0.48 | 0.69 | 0.79 | 0.90 |
| 270 | 0.56 | 0.79 | 0.90 | 0.99 |

*Experiment 3*

The students repeated the procedure from Experiment 1, except that they replaced the distilled $H_2O$ with aqueous solutions of NaCl at 3 different concentrations (see Table 3).

| Table 3 | | | |
|---|---|---|---|
| Soaking time (min) | CMU at an NaCl concentration (in M*) of: | | |
| | 0.5 | 1.0 | 3.0 |
| 20 | 0.13 | 0.12 | 0.09 |
| 40 | 0.22 | 0.20 | 0.17 |
| 60 | 0.26 | 0.23 | 0.20 |
| 90 | 0.32 | 0.28 | 0.25 |
| 120 | 0.37 | 0.32 | 0.29 |
| 180 | 0.42 | 0.38 | 0.33 |
| 270 | 0.47 | 0.41 | 0.38 |
| *moles of NaCl per liter of solution | | | |

13. According to the results of Experiment 2, soaking chickpeas in distilled $H_2O$ for what length of time and at what temperature resulted in the greatest absorption of $H_2O$ ?

|  | soaking time | temperature |
|---|---|---|
| A. | 120 min | 30°C |
| B. | 120 min | 50°C |
| C. | 270 min | 30°C |
| D. | 270 min | 50°C |

14. If a 2.0 M NaCl solution had been tested in Experiment 3, the CMU at 90 min would most likely have been:

F. less than 0.20.
G. between 0.20 and 0.25.
H. between 0.25 and 0.28.
J. greater than 0.28.

15. Suppose the procedure of Experiment 1 is repeated at a temperature of 15°C. Based on the results of Experiments 1 and 2, a soaking time of 120 min will most likely result in a CMU that is:

   A. less than 0.31.
   B. between 0.31 and 0.36.
   C. between 0.36 and 0.47.
   D. greater than 0.47.

16. Consider the group of chickpeas in Experiment 1 that were soaked in the distilled $H_2O$ for 60 min. If these chickpeas had *not* been patted dry after being removed from the $H_2O$, would their CMU more likely have been greater than or less than the value shown in Table 1 for a soaking time of 60 min ?

   F. Greater, because their $CM_f$ would have been greater.
   G. Greater, because their $CM_f$ would have been less.
   H. Less, because their $CM_f$ would have been greater.
   J. Less, because their $CM_f$ would have been less.

17. Upon completion of Experiment 1, how many chickpeas had *not* been removed from the distilled $H_2O$ ?

   A. 15
   B. 20
   C. 25
   D. 30

18. Consider the results of Experiments 1 and 3. At any given soaking time, compared with the CMU of the chickpeas soaked in distilled $H_2O$, the CMU of the chickpeas soaked in an NaCl solution was:

   F. always greater.
   G. always less.
   H. always the same.
   J. sometimes greater and sometimes less, depending on the NaCl concentration.

19. Consider the $CM_f$ of any group of soaked chickpeas in Experiment 1. Also consider the $CM_i$ of the sample of dried chickpeas in Experiment 1. Was the $CM_f$ greater than, less than, or equal to the $CM_i$ ?

   A. Greater
   B. Less
   C. Equal
   D. Cannot be determined from the given information

**GO ON TO THE NEXT PAGE.**

**Passage IV**

Carbon dioxide ($CO_2$) is consumed during photosynthesis and produced during cellular respiration. Photosynthesis and cellular respiration can be summarized by equations 1 and 2, respectively:

1) $6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

2) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$
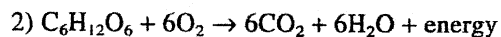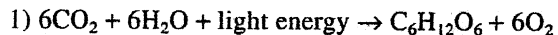
When $CO_2$ dissolves in an aqueous solution, an acid is formed. Thus, the pH of an aqueous solution is affected by the concentration of $CO_2$ dissolved in the solution. A student performed an experiment to determine how the pH of an aqueous solution is affected by the addition to the solution of an organism that is undergoing both photosynthesis and cellular respiration, an organism that is undergoing cellular respiration but not photosynthesis, or both such organisms.

*Experiment*

The student prepared a sterile aqueous solution containing *bromothymol blue*. A bromothymol blue solution can be yellow, green, or blue in color, depending on its pH (see Table 1). The student's solution was green.

| Table 1 | |
|---|---|
| pH | Color of bromothymol blue solution |
| < 6.0 | yellow |
| 6.0–7.6 | green |
| > 7.6 | blue |

The student placed 10 mL of the solution into each of 8 sterile tubes (Tubes 1–8). Then she added a piece of *elodea* (a water plant), a snail, or both to each of Tubes 3–8, placed a cap on each of Tubes 1–8, and incubated all 8 tubes at 25°C for 24 hr. During the incubation, each tube received either no light for 24 hr (dark treatment) or constant light for 24 hr (light treatment). Table 2 lists, for each tube, the organism(s) present (if either), whether the dark or the light treatment was received, and the color of the solution at the end of the 24 hr incubation.

| Table 2 | | | | |
|---|---|---|---|---|
| Tube | Elodea present | Snail present | Dark or light treatment | Color at the end of 24 hr incubation |
| 1 | no | no | dark | green |
| 2 | no | no | light | green |
| 3 | yes | no | dark | yellow |
| 4 | yes | no | light | green |
| 5 | no | yes | dark | yellow |
| 6 | no | yes | light | yellow |
| 7 | yes | yes | dark | yellow |
| 8 | yes | yes | light | green |

20. Suppose that there had been no bromothymol blue in the solution placed in the tubes. Which of the following pieces of equipment would have best allowed the students to determine if the concentration of $CO_2$ dissolved in the solution changed during the 24 hr incubation?

F. Balance
G. Meterstick
H. Microscope
J. pH meter

21. At the end of the 24 hr incubation, the pH of the solution in Tube 1 was closest to which of the following values?

A. 2.0
B. 4.0
C. 7.0
D. 10.0

22. The conditions for Tube 3 and Tube 5 differed in which of the following ways? Tube 3:

    F. was incubated in the dark, whereas Tube 5 was incubated in the light.
    G. was incubated in the light, whereas Tube 5 was incubated in the dark.
    H. contained an organism that is an autotroph, whereas Tube 5 contained an organism that is a heterotroph.
    J. contained an organism that is a heterotroph, whereas Tube 5 contained an organism that is an autotroph.

23. The student had hypothesized that in the absence of photosynthesis and cellular respiration, light would break down the bromothymol blue in the solution during the 24 hr incubation, causing the solution to become yellow. Are the results of the experiment consistent with this hypothesis?

    A. Yes; the solution in Tube 2 was yellow at the end of the 24 hr incubation.
    B. Yes; the solution in Tube 5 was yellow at the end of the 24 hr incubation.
    C. No; the solution in Tube 2 was green at the end of the 24 hr incubation.
    D. No; the solution in Tube 5 was green at the end of the 24 hr incubation.

24. At the end of the 24 hr incubation, why was the color of the bromothymol blue solution in Tube 7 different from the color of the bromothymol blue solution in Tube 8 ? In the absence of light, the elodea in Tube 7 could not undergo:

    F. photosynthesis, so it consumed less $CO_2$ than did the elodea in Tube 8.
    G. photosynthesis, so it consumed more $CO_2$ than did the elodea in Tube 8.
    H. cellular respiration, so it consumed less $CO_2$ than did the elodea in Tube 8.
    J. cellular respiration, so it consumed more $CO_2$ than did the elodea in Tube 8.

25. At the end of the 24 hr incubation, the student removed the snail from Tube 6 and added 10 drops of a new solution, causing the color of the bromothymol blue solution in the tube to change to blue. Was the new solution more likely acidic or basic?

    A. Acidic, because the pH of the bromothymol blue solution increased when the new solution was added.
    B. Acidic, because the pH of the bromothymol blue solution decreased when the new solution was added.
    C. Basic, because the pH of the bromothymol blue solution increased when the new solution was added.
    D. Basic, because the pH of the bromothymol blue solution decreased when the new solution was added.

26. Suppose that an additional tube, Tube 9, had been included in the experiment and that Tube 9 contained a small fish, but no elodea or snail, and received the light treatment. At the end of the 24 hr incubation, would the color of the bromothymol blue solution in Tube 9 more likely have been yellow or blue?

    F. Yellow, because the fish would have undergone photosynthesis, consuming $CO_2$.
    G. Yellow, because the fish would have undergone cellular respiration, producing $CO_2$.
    H. Blue, because the fish would have undergone photosynthesis, consuming $CO_2$.
    J. Blue, because the fish would have undergone cellular respiration, producing $CO_2$.
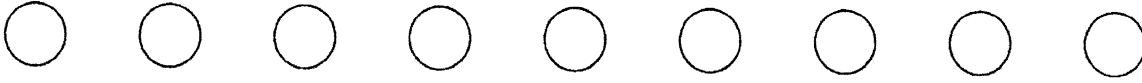
## Passage V

If an object is at rest and the sum of the forces acting on it is zero, the object is in a state of *static equilibrium*. In each trial of 2 experiments on static equilibrium, 3 cables and a cylinder were arranged as shown in Figure 1.
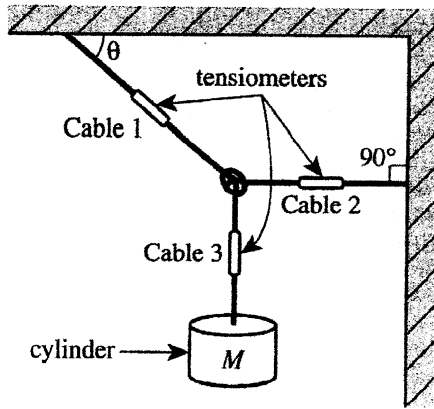


Figure 1

Cables 1, 2, and 3, each with its own *tensiometer* (a device used to measure tension), were joined with a single knot. The free ends of Cables 1 and 2 were attached to an L-shaped support, and a cylinder of mass $M$ was suspended from the free end of Cable 3. Cable 1 made an angle $\theta$ with the top of the support, and Cable 2 made a 90° angle with the side of the support. None of the cables stretched under tension. The tension forces acting on the knot, which was in static equilibrium, are shown in Figure 2.
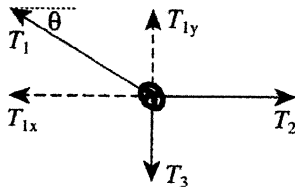


Figure 2

The tension in Cable 1, $T_1$, had a horizontal component, $T_{1x}$, and a vertical component, $T_{1y}$. The tension in Cable 2, $T_2$, was purely horizontal, and the tension in Cable 3, $T_3$, was purely vertical.

### Experiment 1

In Trials 1–5, $M$ was 1.0 kg and $\theta$ was varied. Table 1 lists $\theta$, in degrees, as well as $T_{1x}$, $T_{1y}$, $T_2$, and $T_3$, each in newtons (N), for each trial.

| Table 1 | | | | | |
|---|---|---|---|---|---|
| Trial | $\theta$ | $T_{1x}$ (N) | $T_{1y}$ (N) | $T_2$ (N) | $T_3$ (N) |
| 1 | 10° | −55.6 | 9.8 | 55.6 | −9.8 |
| 2 | 30° | −17.0 | 9.8 | 17.0 | −9.8 |
| 3 | 50° | −8.2 | 9.8 | 8.2 | −9.8 |
| 4 | 70° | −3.6 | 9.8 | 3.6 | −9.8 |
| 5 | 90° | 0.0 | 9.8 | 0.0 | −9.8 |

### Experiment 2

In Trials 6–10, $M$ was varied and $\theta$ was 50°. Table 2 lists $M$ as well as $T_{1x}$, $T_{1y}$, $T_2$, and $T_3$ for each trial.

| Table 2 | | | | | |
|---|---|---|---|---|---|
| Trial | $M$ (kg) | $T_{1x}$ (N) | $T_{1y}$ (N) | $T_2$ (N) | $T_3$ (N) |
| 6 | 2.0 | −16.4 | 19.6 | 16.4 | −19.6 |
| 7 | 3.0 | −24.7 | 29.4 | 24.7 | −29.4 |
| 8 | 4.0 | −32.9 | 39.2 | 32.9 | −39.2 |
| 9 | 5.0 | −41.1 | 49.0 | 41.1 | −49.0 |
| 10 | 6.0 | −49.3 | 58.8 | 49.3 | −58.8 |

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**GO ON TO THE NEXT PAGE.**

27. According to the results of Experiment 1, as $\theta$ increased, the tension in Cable 2:

   A. increased only.
   B. decreased only.
   C. remained constant.
   D. varied, but with no general trend.

28. Based on the results of Experiments 1 and 2, which of the following expressions was always equal to zero?

   F. $T_{1y} + T_3$
   G. $T_{1y} - T_3$
   H. $T_2 + T_3$
   J. $T_2 - T_3$

29. Suppose that Cable 2 was attached to the L-shaped support using a bracket that has a maximum tension rating of 51 N (meaning that it is unsafe to assume that the bracket can support forces greater than 51 N). Based on the results of the experiments, was it safe to use this bracket?

   A. Yes, because $T_2$ exceeded 51 N in one of the trials.
   B. Yes, because $T_2$ did not exceed 51 N in any of the trials.
   C. No, because $T_2$ exceeded 51 N in one of the trials.
   D. No, because $T_2$ did not exceed 51 N in any of the trials.

30. Based on the results of Experiment 1, in order for the absolute value of $T_{1x}$ to be equal to $T_{1y}$, what angle should Cable 1 make with the top of the support?

   F. 45°
   G. 55°
   H. 65°
   J. 75°

31. Suppose that in Experiment 2 a trial had been performed in which $T_{1y}$ was 68.6 N. The mass of the cylinder in this trial would most likely have been:

   A. less than 6.0 kg.
   B. between 6.0 kg and 8.0 kg.
   C. between 8.0 kg and 10.0 kg.
   D. greater than 10.0 kg.

32. Which of the following statements about $\theta$ or $M$ summarizes an important difference between the 2 experiments? In Experiment 1:

   F. $\theta$ was an independent variable, whereas in Experiment 2, $\theta$ was held constant.
   G. $\theta$ was a dependent variable, whereas in Experiment 2, $\theta$ was held constant.
   H. $M$ was an independent variable, whereas in Experiment 2, $M$ was held constant.
   J. $M$ was a dependent variable, whereas in Experiment 2, $M$ was held constant.

33. A vector quantity, such as tension, may be written as $A\hat{x} + B\hat{y}$, where $A$ is the vector's horizontal component and $B$ is the vector's vertical component. For example, the tension (in N) in Cable 1 during Trial 1 could be written as $-55.6\hat{x} + 9.8\hat{y}$. Which of the following expressions gives the tension (in N) in *Cable 2* during Trial 1 ?

   A. $-55.6\hat{x} - 9.8\hat{y}$
   B. $-55.6\hat{x} + 0.0\hat{y}$
   C. $55.6\hat{x} - 9.8\hat{y}$
   D. $55.6\hat{x} + 0.0\hat{y}$

## Passage VI

In the Chryse Planitia area of Mars's surface, numerous winding channels are visible. The channels, some of which are 100 km long, were formed more than 3 billion years ago (bya). Two scientists discuss whether these channels were formed by liquid $H_2O$ or by liquid $CO_2$.

*Scientist 1*

Unlike today, Mars was warm enough prior to 3 bya for liquid $H_2O$ to exist on the surface. Prior to the formation of the channels, a large volume of liquid $H_2O$ slowly accumulated in a basin within the Chryse Planitia. Once the volume became great enough, the liquid $H_2O$ was released suddenly from the basin. The rapidly flowing liquid $H_2O$ carried away rocks and soil, forming the channels. On Earth, similar features called *outflow channels* are produced by the sudden release of a large volume of liquid $H_2O$ from a basin.

*Grey hematite* (a mineral) is abundant on Mars's surface within the Chryse Planitia. On Earth, this mineral is associated exclusively with liquid $H_2O$. Even today, large quantities of frozen $H_2O$ are still present in Mars's polar regions.

*Scientist 2*

Before 3 bya, large volumes of $CO_2$ gas were present a short distance below the surface in the Chryse Planitia. Eventually, the subsurface pressure due to the weight of the overlying rocks and soil became great enough to change the $CO_2$ to a liquid. When a later major event such as an asteroid impact removed most of the overlying material, the liquid $CO_2$ quickly moved up to and then along the surface. The rapidly flowing liquid $CO_2$ carried away rocks and soil, forming the channels. On Earth, gases or liquids that have been under pressure belowground are released to the surface during some volcanic eruptions. These *pyroclastic flows* move rapidly along the ground, forming channels by carrying away rocks and soil.

Since Mars's formation, its average surface temperature has never been greater than −50°C. This has made it impossible for a significant amount of liquid $H_2O$ to be present on the surface. If any liquid $H_2O$ had been present on Mars's surface, it would have reacted with $CO_2$ to produce *carbonate rock* (a rock composed of carbonate minerals). No carbonate rock has been found on Mars.

34. Both scientists describe how a flowing liquid formed the channels that are more than 3 billion years old. The process described by each scientist is an example of:

F. erosion.
G. faulting.
H. plate tectonics.
J. volcanism.

35. A study concluded that at all times before 3 bya, the temperature and pressure conditions a short distance below Mars's surface in the Chryse Planitia would have allowed liquid $H_2O$ to exist but would not have allowed liquid $CO_2$ to exist. This finding is *inconsistent* with the discussion(s) of which of the scientists, if either?

A. Scientist 1 only
B. Scientist 2 only
C. Both scientists
D. Neither scientist

36. Consider Scientist 1's and Scientist 2's assertions about the source of the liquid that formed the channels in the Chryse Planitia. According to Scientist 1, was the source on the surface or below the surface; and according to Scientist 2, was the source on the surface or below the surface?

|  | Scientist 1 | Scientist 2 |
|---|---|---|
| F. | on the surface | on the surface |
| G. | on the surface | below the surface |
| H. | below the surface | on the surface |
| J. | below the surface | below the surface |

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37. Studies have shown that prior to 3 bya, liquid $CO_2$, once it reached Mars's surface, would have evaporated completely before it had flowed 2 km. Does this information support or weaken the viewpoint of Scientist 2 ?

    A. It supports Scientist 2's viewpoint because none of the channels in the Chryse Planitia are longer than 2 km.
    B. It supports Scientist 2's viewpoint because all of the channels in the Chryse Planitia are longer than 2 km.
    C. It weakens Scientist 2's viewpoint because all of the channels in the Chryse Planitia are at least 100 km long.
    D. It weakens Scientist 2's viewpoint because at least a few of the channels in the Chryse Planitia are 100 km long.

38. The discovery of which of the following features in the Chryse Planitia, if made today, would provide the best support for Scientist 2's viewpoint?

    F. A thick frozen $H_2O$ layer
    G. A large lake of liquid $H_2O$
    H. A 3.5-billion-year-old mountain
    J. A 3.5-billion-year-old impact crater

39. Suppose liquid $H_2O$ was present on Mars's surface prior to 3 bya. Would Scientist 1 agree that grey hematite might have been present on Mars's surface prior to 3 bya, and would Scientist 2 agree that carbonate rock might have been present on Mars's surface prior to 3 bya ?

    |    | Scientist 1 | Scientist 2 |
    | --- | --- | --- |
    | A. | yes | yes |
    | B. | yes | no |
    | C. | no | yes |
    | D. | no | no |

40. Based on Scientist 2's discussion, did the pressure of rock and soil on subsurface $CO_2$ have the effect of increasing the average distance between $CO_2$ molecules or of decreasing the average distance between $CO_2$ molecules?

    F. Increasing the average distance, because $CO_2$ changed from a liquid to a gas.
    G. Increasing the average distance, because $CO_2$ changed from a gas to a liquid.
    H. Decreasing the average distance, because $CO_2$ changed from a liquid to a gas.
    J. Decreasing the average distance, because $CO_2$ changed from a gas to a liquid.

## END OF TEST 4

## STOP! DO NOT RETURN TO ANY OTHER TEST.

# Test 2: Mathematics—Scoring Key

| | | Reporting Category* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PHM | | | | | | |
| | Key | N | A | F | G | S | IES | MDL |
| 1. | D | | | | | | — | — |
| 2. | F | | | | | | — | |
| 3. | E | | | | | | — | |
| 4. | H | | — | | | | | |
| 5. | C | | | | — | | | |
| 6. | H | | | | | | — | — |
| 7. | C | | | | | | — | |
| 8. | K | | | | | | — | |
| 9. | B | | | | | | — | |
| 10. | H | | | | | | — | |
| 11. | D | | | | | | — | |
| 12. | G | | — | | | | | — |
| 13. | C | | — | | | | | |
| 14. | K | | — | | | | | |
| 15. | D | | — | | | | — | |
| 16. | F | | | | | | | — |
| 17. | B | | | | | — | | — |
| 18. | G | | | | | — | | |
| 19. | B | | | — | | | | |
| 20. | J | | | — | | | | |
| 21. | D | | | | — | | | — |
| 22. | K | | | | | | — | — |
| 23. | C | | | — | | | | |
| 24. | F | | | | | | — | |
| 25. | C | | | — | | | | |
| 26. | H | | | | — | | | |
| 27. | C | — | | | | | | |
| 28. | F | — | | | | | | — |
| 29. | C | | | | | | — | |
| 30. | G | — | | | | | | |

| | | Reporting Category* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PHM | | | | | | |
| | Key | N | A | F | G | S | IES | MDL |
| 31. | E | | | | — | | | |
| 32. | J | | | — | | | | |
| 33. | D | | | | | | — | |
| 34. | G | | | | — | | | |
| 35. | A | | — | | | | | |
| 36. | K | | | | | | — | |
| 37. | A | | | | | | — | |
| 38. | G | | | | | — | | |
| 39. | E | | | | | | — | — |
| 40. | J | | | | | | — | — |
| 41. | C | | | | | | — | — |
| 42. | J | | | | — | | | |
| 43. | D | | | | | | — | — |
| 44. | K | — | | | | | | |
| 45. | A | | | | | | — | |
| 46. | J | | | | | | — | |
| 47. | B | | | — | | | | |
| 48. | F | | | | — | | | |
| 49. | E | | | | | — | | |
| 50. | F | | | | — | | | — |
| 51. | E | | — | | | | | — |
| 52. | G | | | | | | — | |
| 53. | A | | | | — | | | — |
| 54. | G | | | | — | | — | |
| 55. | A | | | | | | — | |
| 56. | J | | — | | | | | |
| 57. | D | | | | — | | | |
| 58. | F | | | | | | — | |
| 59. | A | | | | — | | | |
| 60. | K | — | | | | | | |

Combine the totals of these columns and put in the blank for PHM in the box below.

*Reporting Categories
**PHM** = Preparing for Higher Math
  N = Number & Quantity
  A = Algebra
  F = Functions
  G = Geometry
  S = Statistics & Probability
**IES** = Integrating Essential Skills
**MDL** = Modeling

| Number Correct (Raw Score) for: | |
|---|---|
| Preparing for Higher Math (PHM) (N + A + F + G + S) | ___ (35) |
| Integrating Essential Skills (IES) | ___ (25) |
| Total Number Correct for Mathematics Test (PHM + IES) | ___ (60) |
| Modeling (MDL) (Not included in total number correct for mathematics test raw score) | ___ (18) |

## Test 3: Reading—Scoring Key

| Key | KID | CS | IKI |
|---|---|---|---|
| 1. D | — | | |
| 2. G | — | | |
| 3. D | — | | |
| 4. H | | — | |
| 5. A | | — | |
| 6. J | — | | |
| 7. B | | — | |
| 8. G | — | | |
| 9. C | — | | |
| 10. F | | — | |
| 11. A | | — | |
| 12. H | — | | |
| 13. C | — | | |
| 14. J | — | | |
| 15. C | — | | |
| 16. F | — | | |
| 17. B | | | — |
| 18. G | | — | |
| 19. D | — | | |
| 20. F | | | — |

| Key | KID | CS | IKI |
|---|---|---|---|
| 21. C | | — | |
| 22. G | | — | |
| 23. D | | — | |
| 24. G | | — | |
| 25. C | — | | |
| 26. F | — | | |
| 27. A | — | | |
| 28. G | | | — |
| 29. A | | | — |
| 30. J | | | — |
| 31. D | | — | |
| 32. F | — | | |
| 33. C | — | | |
| 34. J | — | | |
| 35. B | — | | |
| 36. F | — | | |
| 37. D | — | | |
| 38. G | — | | |
| 39. B | — | | |
| 40. H | | — | |

**\*Reporting Categories**
KID = Key Ideas & Details
CS  = Craft & Structure
IKI  = Integration of Knowledge & Ideas

| **Number Correct (Raw Score) for:** | |
|---|---|
| Key Ideas & Details (KID) | ____ (23) |
| Craft & Structure (CS) | ____ (12) |
| Integration of Knowledge & Ideas (IKI) | ____ (5) |
| Total Number Correct for Reading Test (KID + CS + IKI) | ____ (40) |

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## Test 4: Science—Scoring Key

| Key | IOD | SIN | EMI |
|---|---|---|---|
| 1. A | — | | |
| 2. F | — | | |
| 3. C | — | | |
| 4. G | — | | |
| 5. C | — | | |
| 6. J | | | — |
| 7. D | — | | |
| 8. H | | — | |
| 9. B | — | | |
| 10. F | — | | |
| 11. B | — | | |
| 12. G | — | | |
| 13. D | — | | |
| 14. H | | — | |
| 15. C | | — | |
| 16. F | | — | |
| 17. A | | — | |
| 18. G | — | | |
| 19. A | — | | |
| 20. J | | — | |

| Key | IOD | SIN | EMI |
|---|---|---|---|
| 21. C | | | — |
| 22. H | | — | |
| 23. C | | | — |
| 24. F | | | — |
| 25. C | | — | |
| 26. G | | — | |
| 27. B | — | | |
| 28. F | — | | |
| 29. C | | | — |
| 30. F | | — | |
| 31. B | | — | |
| 32. F | | — | |
| 33. D | — | | |
| 34. F | — | | |
| 35. B | | | — |
| 36. G | | | — |
| 37. D | | | — |
| 38. J | | | — |
| 39. A | | | — |
| 40. J | | | — |

**\*Reporting Categories**
IOD = Interpretation of Data
SIN = Scientific Investigation
EMI = Evaluation of Models,
            Inferences & Experimental Results

| **Number Correct (Raw Score) for:** | |
|---|---|
| Interpretation of Data (IOD) | ____ (17) |
| Scientific Investigation (SIN) | ____ (12) |
| Evaluation of Models, Inferences & Experimental Results (EMI) | ____ (11) |
| Total Number Correct for Science Test (IOD + SIN + EMI) | ____ (40) |

# Explanation of Procedures Used to Obtain Scale Scores from Raw Scores

On act of the four tests on which you marked any response, te total number of correct responses yields a raw score. Ue te table below to convert your raw scores to scale scores. for ach test, locate and circle your raw score or the range of ra' scores that includes it in the table below. Then, read acrss to either outside column of the table and circle the scale s:or that corresponds to that raw score. As you determine our scale scores, enter them in the blanks provided on the igt. The highest possible scale score for each test is 36. The loest possible scale score for any test on which you marked ar responses is 1.

Next, ompute the Composite score by averaging the four scale scos. To do this, add your four scale scores and divide the sum r 4. If the resulting number ends in a fraction, round it off to the earest whole number. (Round down any fraction less than one alf; round up any fraction that is one-half or more.) Enter th number in the blank. This is your Composite score. The higest possible Composite score is 36. The lowest possible Composite score is 1.

NOTE: If you left a test completely blank and marked no items, do not list a scale score for that test. If any test was completely blank, do not calculate a Composite score.

| Scale Score | Test 1 English | Test 2 Mathematics | Test 3 Reading | Test 4 Science | Scale Score |
|---|---|---|---|---|---|
| 36 | 74-75 | 59-60 | 40 | 39-40 | 36 |
| 35 | 71-73 | 57-58 | 39 | 38 | 35 |
| 34 | 70 | 56 | 37-38 | 37 | 34 |
| 33 | 68-69 | 55 | 36 | 36 | 33 |
| 32 | 67 | 54 | 35 | 35 | 32 |
| 31 | 66 | 52-53 | 34 | 34 | 31 |
| 30 | 64-65 | 50-51 | 33 | — | 30 |
| 29 | 62-63 | 48-49 | 32 | 33 | 29 |
| 28 | 61 | 46-47 | 31 | 32 | 28 |
| 27 | 59-60 | 43-45 | 30 | 31 | 27 |
| 26 | 57-58 | 40-42 | 29 | 29-30 | 26 |
| 25 | 55-56 | 37-39 | 28 | 28 | 25 |
| 24 | 52-54 | 34-36 | 27 | 26-27 | 24 |
| 23 | 49-51 | 32-33 | 26 | 25 | 23 |
| 22 | 46-48 | 30-31 | 24-25 | 23-24 | 22 |
| 21 | 43-45 | 28-29 | 23 | 21-22 | 21 |
| 20 | 41-42 | 27 | 22 | 20 | 20 |
| 19 | 39-40 | 25-26 | 20-21 | 18-19 | 19 |
| 18 | 37-38 | 22-24 | 19 | 17 | 18 |
| 17 | 35-36 | 19-21 | 17-18 | 16 | 17 |
| 16 | 32-34 | 15-18 | 16 | 14-15 | 16 |
| 15 | 29-31 | 12-14 | 14-15 | 13 | 15 |
| 14 | 26-28 | 10-11 | 13 | 12 | 14 |
| 13 | 24-25 | 8-9 | 12 | 10-11 | 13 |
| 12 | 23 | 6-7 | 10-11 | 9 | 12 |
| 11 | 20-22 | 5 | 9 | 8 | 11 |
| 10 | 17-19 | 4 | 8 | 7 | 10 |
| 9 | 15-16 | — | 7 | 6 | 9 |
| 8 | 13-14 | 3 | 6 | 5 | 8 |
| 7 | 10-12 | 2 | 5 | 4 | 7 |
| 6 | 8-9 | — | 4 | 3 | 6 |
| 5 | 6-7 | — | 3 | — | 5 |
| 4 | 5 | 1 | — | 2 | 4 |
| 3 | 3-4 | — | 2 | 1 | 3 |
| 2 | 2 | — | 1 | — | 2 |
| 1 | 0-1 | 0 | 0 | 0 | 1 |