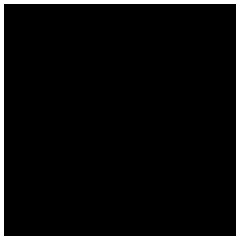
Form G20

(June 2024)



The ACT®

2023 | 2024

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.

ACT owns the test questions and responses, and you may not share them with anyone in any form.

Directions

This booklet contains tests in English, mathematics, reading, and science. These tests measure skills and abilities highly related to high school course work and success in college. **Calculators may be used on the mathematics test only.**

The questions in each test are numbered, and the suggested answers for each question are lettered. On the answer document, the rows of ovals are numbered to match the questions, and the ovals in each row are lettered to correspond to the suggested answers.

For each question, first decide which answer is best. Next, locate on the answer document the row of ovals numbered the same as the question. Then, locate the oval in that row lettered the same as your answer. Finally, fill in the oval completely. Use a soft lead pencil and make your marks heavy and black. **Do not use ink or a mechanical pencil.**

Mark only one answer to each question. If you change your mind about an answer, erase your first mark thoroughly before marking your new answer. For each question, make certain that you mark in the row of ovals with the same number as the question.

Only responses marked on your answer document will be scored. Your score on each test will be based only on the number of questions you answer correctly during the time allowed for that test. You will **not** be penalized for guessing. **It is to your advantage to answer every question even if you must guess.**

You may work on each test **only** when the testing staff tells you to do so. If you finish a test before time is called for that test, you should use the time remaining to reconsider questions you are uncertain about in that test. You may **not** look back to a test on which time has already been called, and you may **not** go ahead to another test. To do so will disqualify you from the examination.

Lay your pencil down immediately when time is called at the end of each test. You may **not** for any reason fill in or alter ovals for a test after time is called for that test. To do so will disqualify you from the examination.

Do not fold or tear the pages of your test booklet.

DO NOT OPEN THIS BOOKLET UNTIL TOLD TO DO SO.

ENGLISH TEST

45 Minutes—75 Questions

DIRECTIONS: In the five passages that follow, certain words and phrases are underlined and numbered. In the right-hand column, you will find alternatives for the underlined part. In most cases, you are to choose the one that best expresses the idea, makes the statement appropriate for standard written English, or is worded most consistently with the style and tone of the passage as a whole. If you think the original version is best, choose "NO CHANGE." In some cases, you will find in the right-hand column a question about the underlined part. You are to choose the best answer to the question.

You will also find questions about a section of the passage, or about the passage as a whole. These questions do not refer to an underlined portion of the passage, but rather are identified by a number or numbers in a box.

For each question, choose the alternative you consider best and fill in the corresponding oval on your answer document. Read each passage through once before you begin to answer the questions that accompany it. For many of the questions, you must read several sentences beyond the question to determine the answer. Be sure that you have read far enough ahead each time you choose an alternative.

PASSAGE I

Violet Palmer: The Right Call

Violet Palmer made history when she refereed a game between the Grizzlies[1] and the Mavericks on October 31, 1997. Never before had a woman refereed a regular-season game for the National Basketball Association (NBA)—which has eighty-two games[2] during its regular season.[2] But, having officiated amateur and professional games for years[3] Palmer had proven herself. She was experienced, she was knowledgeable,[4] and, most of all, ready.

1. **A.** NO CHANGE
B. game between the Grizzlies,
C. game, between the Grizzlies,
D. game, between the Grizzlies

2. Given that all the choices are accurate, which one is most relevant to the discussion of Palmer making history?

F. NO CHANGE
G. or for any major US men's professional sports league.
H. whose regular season runs from October to June.
J. which contained twenty-nine teams at the time.

3. **A.** NO CHANGE
B. amateur, and professional games, for years
C. amateur, and professional games for years,
D. amateur and professional games for years,

4. **F.** NO CHANGE
G. she had the knowledge,
H. was knowledgeable,
J. knowledgeable,

Palmer commenced her referee vocational pastime at [5] a parks and recreation department near Los Angeles in 1987 and soon afterward to begin [6] working high school games. Only a year later, the National Collegiate Athletic Association (NCAA) recruited her. The NCAA, like the NBA, evaluates its [7] referees throughout the season. Both leagues then assign the most prestigious games to the referees who make the correct calls most consistently. Palmer soon stretched to [8] the highest echelons of college basketball, officiating [9] a women's semifinal game five times and the national championship game twice.

The NBA took notice of Palmer and, in 1995, invited her to officiate off-season games, an invitation many college referees never receive. Three seasons later, Palmer became one of only sixty-two NBA regular-season referees. Palmer's refereeing career began in 1987. [10] She was promoted two years faster than the average referee.

At first, some questioned whether Palmer could handle the NBA. While referees at all levels call fouls and regulates [11] games, NBA referees preside over [12] high-stakes games played by the fastest and best players in the world. With a calm, no-nonsense demeanor and skillful officiating, [13] Palmer silenced her skeptics.

5. **A.** NO CHANGE
B. underwent the dawn of her career at
C. started refereeing for
D. first did ref stuff for

6. **F.** NO CHANGE
G. and soon afterward began
H. soon afterward beginning
J. soon afterward began

7. **A.** NO CHANGE
B. they're
C. there
D. it's

8. **F.** NO CHANGE
G. extended to
H. ascended to
J. gripped

9. **A.** NO CHANGE
B. basketball Palmer officiated
C. basketball, she officiated
D. basketball she officiated

10. The writer is considering deleting the underlined sentence. Should the sentence be kept or deleted?

F. Kept, because it is consistent with the paragraph's focus on the start of Palmer's career.
G. Kept, because it establishes when Palmer began to referee basketball games.
H. Deleted, because it repeats information that was presented earlier in the essay.
J. Deleted, because it is unrelated to the essay's discussion of Palmer's occupation.

11. **A.** NO CHANGE
B. is required to call fouls and regulate
C. calls fouls and regulates
D. call fouls and regulate

12. **F.** NO CHANGE
G. from
H. on
J. DELETE the underlined portion.

13. If the writer were to delete the underlined portion, the essay would primarily lose details that:

A. help explain why the NBA is challenging for referees.
B. specify some of Palmer's attributes as a referee.
C. identify other referees' traits that Palmer admired.
D. establish that Palmer won over her critics.

After four years in the NBA, she noticed that people no longer talked about her gender, she was simply a referee.

14. F. NO CHANGE
G. gender; because
H. gender;
J. gender

Although other women have become NBA referees after Palmer, she doesn't see herself as a pioneer. Even so, she didn't initially seek a career in the NBA, but when the opportunity came, she embraced it. She says, "If you give me a challenge, I'm going to take it."

15. A. NO CHANGE
B. Otherwise, she
C. That said, she
D. She

PASSAGE II

Schiphol Airport's Sound Solution

[1]

Each day, more than 1,600 flights go through Amsterdam's Schiphol Airport ranks as Europe's fourth busiest. Unfortunately, such a volume of takeoffs and landings causes volume of a different sort: noise. [A] In the early 2000s, as Schiphol grew ever busier, nearby residents increasingly complained about the noise. The roaring of jets was worst in the Hoofddorp Noord neighborhood.

16. F. NO CHANGE
G. More than 1,600 flights a day depart or arrive at
H. It has more than 1,600 flights a day,
J. With more than 1,600 flights a day,

17. The writer wants to provide specific information about the extent of the area affected by the airport's noise. Given that all the choices are accurate, which one best accomplishes that goal?

A. NO CHANGE
B. could be heard up to eighteen miles away.
C. wasn't going to go away on its own.
D. continued day and night.

[2]

Pledging to curtail the noise, the airport administration hired acoustic scientists to research the problem. As the scientists worked,

18. F. NO CHANGE
G. conduct a methodical investigation of the auditory nuisance.
H. figure out what was up with the racket.
J. get the full scoop.

the seasons changed after farmers plowed many of the fields near the airport. Researchers noticed that the noise, reaching the airport's neighbors: had suddenly decreased. [B] The plowed fields, with their dirt ridges and furrows, somehow diminished the noise.

19. A. NO CHANGE
B. changed when
C. changed, and
D. changed, yet

20. F. NO CHANGE
G. noise, reaching the airport's neighbors
H. noise reaching the airport's neighbors,
J. noise reaching the airport's neighbors

[3]

The researchers set out to replicate the sound-dampening qualities of plowed fields. They tested miniature landform shapes in the lab and full-size versions outside, analyzing how sound waves interacted with various shapes. [C] They also brought in landscape artist Paul de Kort, to add visual appeal to the design.

[4]

The installed design, called Buitenschot Land Park and finished in 2013, are consisted of 150 earthen ridges on eighty acres of land adjacent to the airport. The long, straight, grass-covered ridges stand ten feet tall and run parallel to each other. Groups of these parallel ridges are offset at various angles, which gives the project a warped-checkerboard look. De Kort incorporated paths, playing fields, and art pieces among the ridges—making the strange landscape into a park.

In other words, when sound from the airport encounters the ridges, much of it is deflected skyward, halving the noise that reaches the neighbors.

21. Given that all the choices are true, which one most effectively introduces this paragraph?

A. NO CHANGE
B. became part of a long history of immense landscape engineering projects in the Netherlands.
C. knew that at Schiphol, a plane lands or takes off, on average, once every minute.
D. understood how disruptive the airport's noise could be to nearby residents.

22. **F.** NO CHANGE
G. artist, Paul de Kort,
H. artist, Paul de Kort
J. artist Paul de Kort

23. **A.** NO CHANGE
B. have consisted
C. consists
D. consist

24. **F.** NO CHANGE
G. standing ten feet tall and running
H. stand ten feet tall and running
J. standing ten feet tall and run

25. Which choice most specifically describes the collective physical appearance of the groups of ridges?

A. NO CHANGE
B. a unique aspect when viewed from above.
C. an unmistakably human-made form.
D. a lively visual dynamism.

26. Which of the following alternatives to the underlined portion would NOT be acceptable?

F. ridges, which made
G. ridges, making
H. ridges to make
J. ridges make

27. **A.** NO CHANGE
B. Most importantly,
C. To demonstrate,
D. Specifically,

[5]

The park may have been the world's first landscape project created to mitigate sound that is the result of airplane noise, [28] but it won't be the last. As airports worldwide grow bigger and busier, they're looking at Schiphol's solution as a neighborhood-friendly way [29] to quell the din. [D]

28. **F.** NO CHANGE
G. noisiness stemming from airplanes,
H. airplanes' noise effects,
J. airplane noise,

29. **A.** NO CHANGE
B. solution, as a neighborhood-friendly way,
C. solution; as a neighborhood-friendly way
D. solution, as a neighborhood-friendly way

Question 30 asks about the preceding passage as a whole.

30. The writer is considering adding the following sentence to the essay:

> Particularly, jet engines produce thunderous rumbling when running at high power for takeoff.

If the writer were to add this sentence, it would most logically be placed at:

F. Point A in Paragraph 1.
G. Point B in Paragraph 2.
H. Point C in Paragraph 3.
J. Point D in Paragraph 5.

PASSAGE III

Microbial Alchemy

[1]

In the Middle Ages, alchemists attempted to transmute base metals into gold. For example, the [31] process—producing four chemical changes in a base metal—allegedly rendered a gold-producing substance called the philosopher's stone. Today, we know this is nonsense. [A] But in 2013, Kazem Kashefi and Adam Brown, professors at Michigan State University, demonstrated that gold could be extracted through a biochemical process. The [32] bacterium *Cupriavidus metallidurans* metabolizes the toxic chemical gold chloride, it creates a by-product: 24-karat gold. [B]

31. **A.** NO CHANGE
B. Furthermore, the
C. Therefore, the
D. The

32. **F.** NO CHANGE
G. It is when the
H. That is, the
J. When the

[2]

As they were testing whether *C. metallidurans* could produce gold, Kashefi and Brown also assessed (33) the bacterium's hardiness. (33) *C. metallidurans* is an extremophile; (34) a bacterium capable of surviving in extreme chemical conditions. [C] The professors forsook (35) *C. metallidurans* in a bioreactor with increasing amounts of gold chloride. Because no other rations were in the neighborhood, (36) the bacterium was forced to metabolize the toxin to survive. Kashefi compared the bacterium metabolizing gold chloride to a person breathing air. [D] Similar to how a person inhales oxygen and exhales carbon dioxide, the bacterium metabolizes gold chloride and produces 24k gold.

[3]

The professors' method with producing gold (37) isn't cost-affective—(37) the biochemical reaction of gold (38) yields only a few granules. But Kashefi and Brown's experiment suggests other potential uses for *C. metallidurans*. The professors showed that *C. metallidurans* could survive in higher concentrations of gold chloride than the scientific community previously believed to be possible. Kashefi and Brown's thought (39) that the bacterium could have eco-friendly applications.

33. **A.** NO CHANGE
B. *C. metallidurans* also received an assessment of its hardiness performed by Kashefi and Brown.
C. the bacterium also had an assessment of its hardiness done by Kashefi and Brown.
D. the bacterium also got its hardiness assessed by Kashefi and Brown.

34. **F.** NO CHANGE
G. extremophile, and
H. extremophile:
J. extremophile

35. **A.** NO CHANGE
B. isolated
C. severed
D. exiled

36. **F.** NO CHANGE
G. sustenance was available,
H. grub was in the vicinity,
J. eats were in the house,

37. **A.** NO CHANGE
B. with producing gold isn't cost-effective—
C. for producing gold isn't cost-effective—
D. for producing gold isn't cost-affective—

38. The best placement for the underlined portion would be:

F. where it is now.
G. after the word *yields*.
H. after the word *only*.
J. after the word *granules* (and before the period).

39. **A.** NO CHANGE
B. Brown thinking
C. Brown to think
D. Brown think

However, many waterways have been highly polluted
40
with toxins such as arsenic and uranium. *C. metallidurans*,

by metabolizing such toxins, could reduce pollution
41
levels. As clean water becomes an increasingly critical

resource, such an application could make *C. metallidurans*
42

worth its weight in gold.
43

40. **F.** NO CHANGE
G. For instance,
H. Likewise,
J. In effect,

41. If the writer were to delete the underlined portion (adjusting the punctuation as needed), the essay would primarily lose:

A. a suggestion that toxins are not as damaging to waterways as was once believed.
B. an indication of how *C. metallidurans* could reduce pollution levels.
C. a suggestion about how *C. metallidurans* could be genetically engineered in laboratories.
D. an indication that *C. metallidurans* can metabolize arsenic and uranium more efficiently than it can metabolize gold chloride.

42. **F.** NO CHANGE
G. resource, and such
H. resource; such
J. resource. Such

43. **A.** NO CHANGE
B. they're
C. their
D. it's

Questions 44 and 45 ask about the preceding passage as a whole.

44. The writer is considering adding the following sentence to the essay:

Medieval alchemy was a pseudoscience.

If the writer were to add this sentence, it would most logically be placed at:

F. Point A in Paragraph 1.
G. Point B in Paragraph 1.
H. Point C in Paragraph 2.
J. Point D in Paragraph 2.

45. Suppose the writer's primary purpose had been to provide a historical overview of a particular discipline of science. Would this essay accomplish that goal?

A. Yes, because it suggests potential applications of Kashefi and Brown's process for creating gold.
B. Yes, because it identifies key developments in alchemy's history that led to Kashefi and Brown's process for creating gold.
C. No, because it focuses on how *C. metallidurans* created gold in Kashefi and Brown's experiment and potential practical uses of the bacterium.
D. No, because it mainly details *C. metallidurans*'s evolution and why the bacterium can metabolize various toxins.

PASSAGE IV

Sculpting the Wind

Across the rolling green moorlands of Burnley, a town, in Lancashire, England, the sounds of chirping birds and bleating sheep remind tourists of what the town looked like long ago. The sculpture, a ten-foot-tall funnel of galvanized steel pipes shaped to resemble a windswept tree, overlooks Burnley from the top of the town's highest hill. For the citizens below, this work of art has become a source of pride, a symbol linking nature to industry and past to present.

A bustling mill town during England's Industrial Revolution, Burnley has only recently reestablished it as an enterprising manufacturing town. In 2004, hoping to bolster the town's economy, the Burnley council and Mid Pennine Arts commissioned a piece of art that would draw tourists to the area. The architects they hired, Mike Tonkin and Anna Liu, found inspiration in the region's

46. **F.** NO CHANGE
G. Burnley, a town in Lancashire, England,
H. Burnley, a town in Lancashire, England
J. Burnley a town in Lancashire, England,

47. Which choice most effectively introduces the subject of the essay?

A. NO CHANGE
B. mingle with the haunting steel hum of the Singing Ringing Tree.
C. create a perfect backdrop for all types of art.
D. can be heard.

48. If the writer were to delete the underlined portion (ending the sentence with a period), the essay would primarily lose:

F. a description of the process the artists went through in choosing where to place the sculpture.
G. specific information that establishes Burnley as a town surrounded by rolling fields.
H. a detail that helps convey where in Burnley the sculpture is located.
J. an indication of the difficulty involved in crafting the sculpture.

49. Given that all the choices are accurate, which one creates a sentence that expands upon the ideas presented in the last sentence of the previous paragraph?

A. NO CHANGE
B. Boasting a population of more than 86,000 people,
C. Located 22 miles north of Manchester,
D. Named for the river Burn,

50. **F.** NO CHANGE
G. themself
H. itself
J. DELETE the underlined portion.

persistent winds, which can reach speeds of sixty miles per hour. [51]

Wanting to assemble [52] the winds into the sculpture, Tonkin and Liu modeled the tree after the panpipe.

This wind instrument is [53] comprised of a series of open, hollow tubes that are arranged into a row and bound together. The tubes, which vary in length, produce musical notes when the musician blows across the tops of them. Coincidentally, [54] Tonkin and Liu reasoned that winds blowing across a sculpture made of pipes could produce the same musical affect. [55]

To form the tree's bent trunk, the architects and their team stacked layers of shorter pipes onto a spiral axis, layers [56] of longer pipes form the top of the tree. Of the 320 pieces of pipe used to creating the sculpture, only 25 actually generate [57] tones. To better catch the wind, each of these "singing" pipes is positioned near the top of the tree.

51. At this point, the writer is considering adding the following true information:

> On average, the month of January has proven to be the windiest month in Burnley.

Should the writer make this addition here?

A. Yes, because it provides a brief overview of how the weather in Burnley changes from season to season.
B. Yes, because it strengthens the writer's claim that Burnley is particularly windy.
C. No, because it deviates from the discussion of how Tonkin and Liu conceived of the sculpture.
D. No, because it fails to describe the wind conditions elsewhere in the region.

52. **F.** NO CHANGE
G. incorporate
H. absorb
J. lump

53. **A.** NO CHANGE
B. that is
C. being
D. DELETE the underlined portion.

54. **F.** NO CHANGE
G. Despite this,
H. Fortunately,
J. DELETE the underlined portion.

55. **A.** NO CHANGE
B. produce the same musical effect.
C. of produced the same musical affect.
D. of produced the same musical effect.

56. **F.** NO CHANGE
G. axis, the layering
H. axis; layers
J. axis and layers

57. **A.** NO CHANGE
B. creating the sculpture, only 25 actually generating
C. create the sculpture, only 25 actually generating
D. create the sculpture, only 25 actually generate

The Singing Ringing Tree creates a mix (58) every day as the wind blows through Burnley. Consistent with the architects' vision the sculpture's eerie, (59) melancholy notes resonate with tourists and citizens alike.

58. Which choice most precisely indicates what the Singing Ringing Tree creates every day?

F. NO CHANGE
G. something new and fresh
H. a unique song
J. something

59. **A.** NO CHANGE
B. vision, the sculpture's eerie,
C. vision, the sculpture's eerie
D. vision the sculpture's eerie

Question 60 asks about the preceding passage as a whole.

60. Suppose the writer's primary purpose had been to describe the creation of a commissioned piece of public art. Would this essay accomplish that purpose?

F. Yes, because it explains that the Singing Ringing Tree was inspired by the panpipe.
G. Yes, because it explains why and how the Singing Ringing Tree was built.
H. No, because it instead highlights architects Tonkin and Liu and their individual accomplishments.
J. No, because it instead focuses on Burnley's improving economy.

PASSAGE V

A Piece of Mexico in Brooklyn

[1]

Inside Librería Donceles, a bookstore conceived by New York–based artist Pablo Helguera, masses of books beckon. Carefully arranged piles rest on small reading tables, on shelves, on the floor. Pieces of furniture—a desk here, a lamp there—punctuates (61) the small Brooklyn warehouse. It, is at once, cozy (62) and intimidating, both chaotic and artful. I walk through slowly, pause to admiring (63) the sculptural stacks of books, the thoughtfully curated sections with titles such as "Poesía" (Poetry) (64) and the less conventional "Teoría Dudosa" (Doubtful Theory).

61. **A.** NO CHANGE
B. has punctuated
C. is punctuating
D. punctuate

62. **F.** NO CHANGE
G. It is at once cozy
H. It is, at once cozy,
J. It is at once cozy,

63. **A.** NO CHANGE
B. slowly and pausing to admire
C. slowly and pause to admiring
D. slowly, pausing to admire

64. **F.** NO CHANGE
G. titles, such as "Poesía" (Poetry),
H. titles such as, "Poesía" (Poetry),
J. titles such as, "Poesía" (Poetry)

Named for Calle Donceles, an avenue in Mexico City
65
that features cobblestones and wrought-iron lampposts,
65
Librería Donceles attempts to connect people to culture through books.

[2]

Approximately two million Spanish speakers live in New York City. Yet Helguera, whom immigrated from
66
Mexico City, couldn't find a secondhand Spanish-language bookstore at all anywhere in all of New York City.
67
Helguera wanted to open up a dialogue regarding cultural history and the connections that people have (or don't have) to their roots. [A] He began trading his drawings for book donations, accumulating a substantial number of used books (around 20,000)
68
for the project.

[3]

[B] To highlight and preserve the lineage and
69
history of the books, Helguera brands the inside covers with yellow stickers. All of the stickers bears
70
the name of the previous owner. Visitors are encouraged to select one book to take home in exchange for a donation in the amount of their choosing. In this way, Helguera hopes, people will feel connected to the experience that Librería Donceles elicits even
71
after they leave the bookstore. [C]

65. Given that all the choices are accurate, which one provides the most relevant information at this point in the essay?

A. NO CHANGE
B. an east–west avenue in Mexico City that is home to several camera supply stores,
C. a street in Mexico City lined with bookstores,
D. a busy street in Mexico City,

66. **F.** NO CHANGE
G. who emigrated from
H. who immigrated of
J. whom emigrated of

67. **A.** NO CHANGE
B. at all despite there being so many Spanish speakers in New York City.
C. for Spanish speakers.
D. anywhere.

68. **F.** NO CHANGE
G. (in the range of 20,000 as an estimated total)
H. (around 20,000 total or thereabouts)
J. (in the range of around 20,000)

69. **A.** NO CHANGE
B. to preserving also the lineage and
C. to preserve the lineage and also
D. preserving the lineage and also

70. **F.** NO CHANGE
G. Every one of the stickers bear
H. Each of the stickers bear
J. Each sticker bears

71. The best placement of the underlined portion would be:

A. where it is now.
B. after the word *that*.
C. after the word *they*.
D. after the word *leave*.

[4]

I settle on a copy of Julio Cortázar's

La Noche Boca Arriba, this is a dog-eared, faded
72
book donated by Juana Vargas. [D] I overhear a man saying that Librería Donceles reminds him exactly of the bookstores he used to go to in Mexico. "Es buena," he says. "It's unlike anything I've ever seen."
73

72. **F.** NO CHANGE
G. *Arriba* this is
H. *Arriba*,
J. *Arriba*

73. Which choice most effectively concludes the essay by demonstrating that Librería Donceles is successful in connecting visitors to their roots?

A. NO CHANGE
B. "It reminds me how much I love books."
C. "It's charming and unexpected."
D. "It feels like home."

Questions 74 and 75 ask about the preceding passage as a whole.

74. The writer wants to add the following sentence to the essay:

> A quiet buzz of excitement fills the space as people converse in both Spanish and English.

This sentence would most logically be placed at:

F. Point A in Paragraph 2.
G. Point B in Paragraph 3.
H. Point C in Paragraph 3.
J. Point D in Paragraph 4.

75. Suppose the writer's primary purpose had been to describe how the direction of Helguera's projects has changed over the years. Would this essay accomplish that purpose?

A. Yes, because it demonstrates the overall significance of Helguera's Librería Donceles project.
B. Yes, because it describes projects that Helguera completed in both Mexico City and New York City.
C. No, because it instead focuses on one project Helguera created during his career.
D. No, because it instead explores Helguera's cultural background.

END OF TEST 1

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

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.

DO YOUR FIGURING HERE.

1. Which of the following expressions is equivalent to $a(5 - a) - 8(a + 6)$?

A. $-4a - 48$
B. $-4a + 6$
C. $-a^2 - 3a - 48$
D. $-a^2 - 3a + 6$
E. $-4a^3 - 48$

2. Because of rising expenses, a motel manager raises the room rate of \$80.00 by 20% to get the new room rate for the motel. What is the new room rate?

F. \$ 16.00
G. \$ 80.20
H. \$ 82.00
J. \$ 96.00
K. \$100.00

3. Which of the following matrices is equal to $5\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$?

A. $\begin{bmatrix} 5 & 2 \\ 3 & 4 \end{bmatrix}$

B. $\begin{bmatrix} 5 & 2 \\ 3 & 20 \end{bmatrix}$

C. $\begin{bmatrix} 1 & 10 \\ 15 & 4 \end{bmatrix}$

D. $\begin{bmatrix} 6 & 7 \\ 8 & 9 \end{bmatrix}$

E. $\begin{bmatrix} 5 & 10 \\ 15 & 20 \end{bmatrix}$

4. A retail sales associate's daily commission during 1 week was \$30 on Monday and Tuesday and \$60 on Wednesday, Thursday, and Friday. What was the associate's average daily commission for these 5 days?

F. \$45
G. \$46
H. \$48
J. \$49
K. \$50

DO YOUR FIGURING HERE.

5. What value of x makes the equation below true?

$$-x + 6 = 3x - 10$$

A. -4
B. -2
C. -1
D. 1
E. 4

6. Fred's cell phone service costs \$25.00 per month and includes 100 minutes. For any minutes used after the 100 minutes, he is charged \$0.10 per minute. Fred has budgeted \$33.00 per month for his cell phone service. What is the maximum number of minutes Fred could use in 1 month without exceeding his budget?

F. 108
G. 132
H. 180
J. 330
K. 430

7. The function $f(c) = \frac{9}{5}c + 32$ gives the temperature, $f(c)$ degrees Fahrenheit, that corresponds to c degrees Celsius. To the nearest 0.1°F, what Fahrenheit temperature corresponds to 13.0°C ?

A. 33.8°F
B. 45.0°F
C. 46.8°F
D. 55.4°F
E. 81.0°F

8. What number, when added to $\frac{1}{3}$, gives a sum that is equal to the sum of $\frac{1}{4}$ and $\frac{1}{6}$?

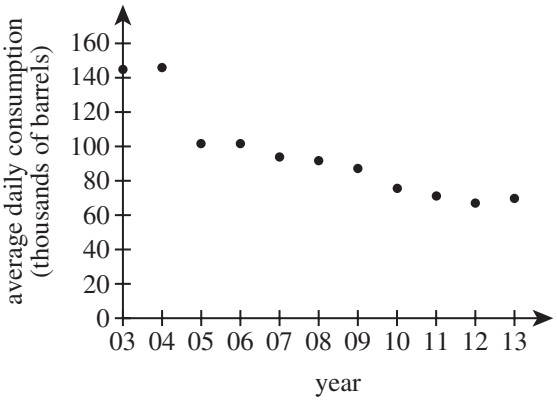
F. $\frac{1}{12}$
G. $\frac{1}{9}$
H. $\frac{1}{7}$
J. $\frac{1}{5}$
K. $\frac{3}{4}$

9. For $\overleftrightarrow{RT}$ shown below, point S is on $\overline{RT}$, the length of $\overline{RS}$ is 6 cm, and the length of $\overline{ST}$ is 20 cm. What is the distance, in centimeters, between T and the midpoint of $\overline{RS}$?

A. 13
B. 16
C. 20
D. 23
E. 26

DO YOUR FIGURING HERE.

10. The graph below shows the average daily consumption, in thousands of barrels, of oil for Uzbekistan for the years 2003 through 2013.



From what year to the following year did the average daily consumption decrease the most?

F. 2003 to 2004
G. 2004 to 2005
H. 2006 to 2007
J. 2009 to 2010
K. 2012 to 2013

11. A rectangular field that measures 300 meters by 175 meters is to be completely fenced along its perimeter. Given that fencing sells for $2.05 per meter, what will the fencing for the field cost?

A. $ 973.75
B. $1,332.50
C. $1,405.00
D. $1,588.75
E. $1,947.50

12. Mary throws a stone from the edge of a cliff. While the stone is in flight, the equation $h = 300 - 30t - 16t^2$ gives the height above the ground, h feet, of the stone at any given time t seconds after being thrown. What is the height, in feet, of the stone exactly 3 seconds after Mary throws the stone?

F. 66
G. 114
H. 162
J. 246
K. 354

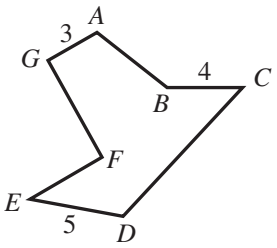
13. What is the median of the data set below?

4, 8, 14, 4, 20

A. 4
B. 8
C. 10
D. 14
E. 16

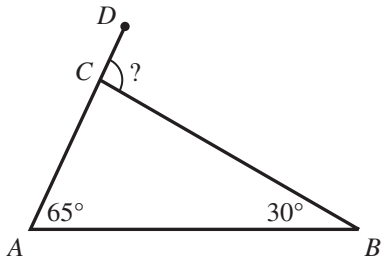
DO YOUR FIGURING HERE.

14. Rafael has made a scale model of City Park, shown below, in which 3 lengths are given in inches. On the model, $\overline{BC}$ represents an actual length of 90 feet in the park. On the model, $\overline{DE}$ represents what actual length, in feet, in the park?



F. 67.5
G. 72
H. 112.5
J. 120
K. 150

15. In the figure below, point C is on $\overline{AD}$, and 2 angle measures of $\triangle ABC$ are given. What is the measure of $\angle BCD$?

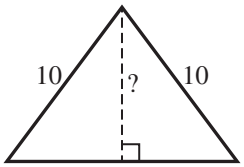


A. 65°
B. 85°
C. 95°
D. 105°
E. 115°

16. The number a is positive and even. The number b is negative and odd. The number $a - b$ is:

F. positive and even.
G. positive and odd.
H. negative and even.
J. negative and odd.
K. zero.

17. The isosceles triangle shown below has congruent legs that are each 10 centimeters long. The perimeter of the triangle is 32 centimeters. What is the length, in centimeters, of the altitude that splits the triangle into 2 congruent right triangles?



A. $\sqrt{44}$
B. 6
C. 7
D. 8
E. 10

18. For all nonzero values of a, the expression $\frac{a^2a^4}{a^6}$ is equal to:

F. 0
G. 1
H. a
J. a^2
K. a^{12}

DO YOUR FIGURING HERE.

19. A 12-foot taut wire has one end attached to the ground and the other end attached to a vertical pole, as shown below. The point of contact of the wire and the pole is 8 feet above the ground. What angle does the wire make with the level ground?

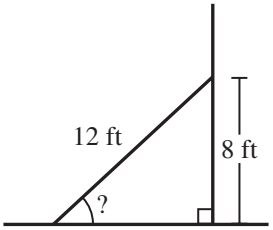
A. $\cos^{-1}\left(\frac{8}{12}\right)$

B. $\csc^{-1}\left(\frac{8}{12}\right)$

C. $\sec^{-1}\left(\frac{8}{12}\right)$

D. $\sin^{-1}\left(\frac{8}{12}\right)$

E. $\tan^{-1}\left(\frac{8}{12}\right)$



20. Marcy is making toys to sell at the local school fair. Each toy costs Marcy $2.25 to make, and she will sell them for $4.05 each. What is the minimum number of toys she can make and sell to earn a profit of at least $81.00 ?

F. 13
G. 16
H. 20
J. 36
K. 45

21. Given functions $f(x) = 4x + 3$ and $g(x) = x^2 - 2$, what is the value of $f(g(-3))$?

A. −83
B. −41
C. −29
D. 31
E. 79

22. Let $z = 4 + 5i$ and $w = 3 + 7i$, where i is the imaginary unit. What is the value of $2z + w$?

F. −28
G. $28i$
H. $11 + 12i$
J. $11 + 17i$
K. $14 + 24i$

23. If $x^2 - 5x - 6 = 0$, what is the sum of the 2 possible values of x ?

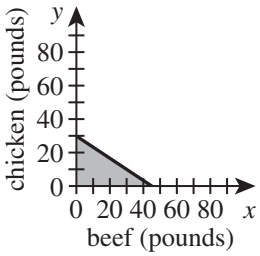
A. −5
B. −1
C. 1
D. 5
E. 6

DO YOUR FIGURING HERE.

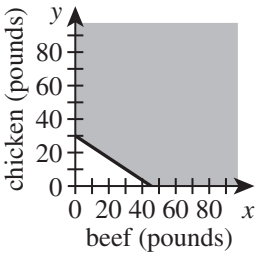
24. Kate is going to buy meat (beef and chicken) for a party. Beef costs $3.00 per pound, chicken costs $2.00 per pound, and Kate has a budget of $90.00 to spend on meat for the party. The shaded region in one of the following graphs represents all and only the possible combinations of beef and chicken Kate can buy while staying within her budget. Which one?

(Note: Do not consider tax.)

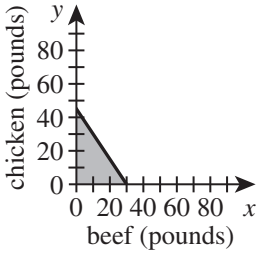
F.



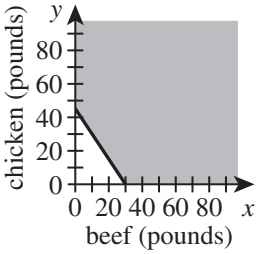
J.



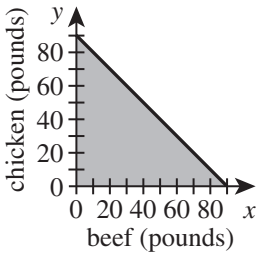
G.



K.



H.



25. Each student in a particular classroom was given a string that was 72 inches long. Each student cut his or her string into pieces of equal length. Which of the following CANNOT be the length, in inches, of any student's pieces?

A. $\frac{1}{16}$

B. $\frac{1}{2}$

C. 1

D. 16

E. 36

DO YOUR FIGURING HERE.

26. The graph of the function $f(x) = -9(x + 1)^2 + 81$ has its vertex at point $(-1,81)$ and intersects the x-axis at points $(-4,0)$ and $(a,0)$. What is the value of a ?

F. $-\frac{81}{5}$

G. $\frac{5}{81}$

H. 2

J. 3

K. 81

27. What fraction of $4\frac{1}{4}$ is $2\frac{1}{8}$?

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 2

D. $2\frac{1}{8}$

E. $2\frac{1}{2}$

28. What is the least positive number that has a remainder of 4 when divided by 6 and a remainder of 5 when divided by 7 ?

F. 22
G. 33
H. 40
J. 42
K. 59

29. Joe, Tom, and Alexis are planning to participate in a 3-person relay for charity. The plan is for Joe to jog his 3 miles at 4 miles per hour (mph), Tom to jog his 3 miles at 5 mph, and then Alexis to jog her 3 miles at 6 mph. In how many hours and minutes does this 3-person team plan to complete the 9-mile relay?

A. 0 hours 36 minutes
B. 1 hour 48 minutes
C. 1 hour 51 minutes
D. 2 hours 15 minutes
E. 2 hours 25 minutes

30. Let θ be an acute angle of a right triangle. Given $\sin\theta = \frac{a}{b}$ and $\tan\theta = \frac{a}{c}$, $\cos\theta = ?$

F. 1

G. $\frac{b}{a}$

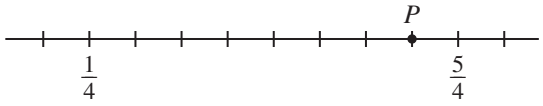
H. $\frac{b}{c}$

J. $\frac{c}{a}$

K. $\frac{c}{b}$

DO YOUR FIGURING HERE.

31. The number line shown below is marked in equal intervals. Two fractions are indicated on the number line. One of the following fractions corresponds to the point marked P. Which one?



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

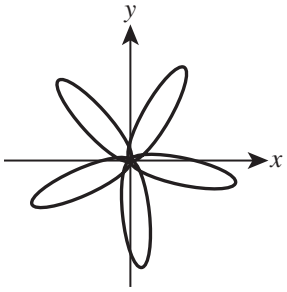
B. $\frac{7}{8}$

C. $\frac{8}{9}$

D. $\frac{4}{4}$

E. $\frac{9}{8}$

32. The graph in the standard (x,y) coordinate plane below has 5 lines of symmetry that all intersect at the origin. What is the smallest positive clockwise rotation about the origin that can be applied to this graph with the result being this graph?



F. 72°
G. 90°
H. 120°
J. 144°
K. 216°

33. The following linear functions are defined either with an equation, a graph, or a table of values. Which of the following functions has the greatest slope?

A. $f(x) = 15$

B. $g(x) = 8x + 7$

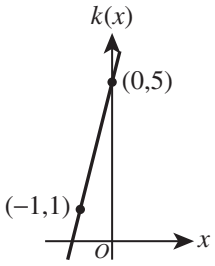
C.

x	$h(x)$
0	6
3	0
11	−16

D.

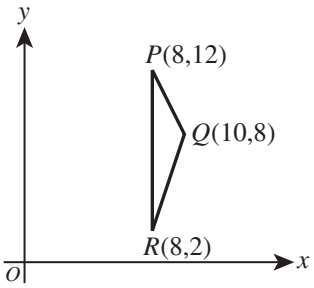
x	$j(x)$
−6	0
4	5
14	10

E.



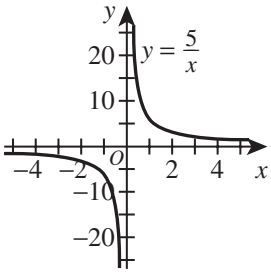
DO YOUR FIGURING HERE.

34. The vertices of $\triangle PQR$ are given in the standard (x,y) coordinate plane below. What is the area, in square coordinate units, of $\triangle PQR$?



F. 6
G. 10
H. 12
J. 20
K. 48

35. The function $y = f(x) = \frac{5}{x}$ is graphed in the standard (x,y) coordinate plane below.



One of the following statements is FALSE. Which one?

A. $f(x)$ decreases for all $x > 0$.
B. $f(x)$ decreases for all $x < 0$.
C. The graph of $f(x)$ has a horizontal asymptote at $y = 0$.
D. The graph of $f(x)$ has a vertical asymptote at $x = 0$.
E. The graph of $f(x)$ has an intercept at (0,0).

36. All students in a high school responded either "Yes" or "No" to the question "Are you studying enough?" The table below gives the number of students in each grade who responded. Two numbers in the table are represented by x and y.

	9th	10th	11th	12th
Yes	85	92	79	102
No	65	x	y	56

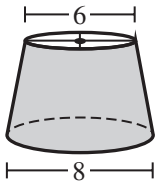
The probability that a randomly selected student from this high school is in 11th grade given that the student responded "No" is $\frac{75}{267}$. One of the following is the value of x. Which one?

F. 71
G. 75
H. 100
J. 113
K. 146

DO YOUR FIGURING HERE.

Use the following information to answer questions 37–39.

Josie has decided to make a new lampshade for her bedroom lamp. She will order materials from a website that offers 4 different print designs and 4 different color schemes that can be used with each design. The top and bottom edges of Josie's current lampshade are parallel circles with diameters of length 6 inches and 8 inches, as pictured below. The centers of the 2 circles are directly above and below one another.



37. What is the ratio of the area of the circle modeled by the top edge of the lampshade to the area of the circle modeled by the bottom edge of the lampshade?

A. 3:7
B. 3:4
C. 9:16
D. 4:3
E. 16:9

38. In order to design her lampshade, Josie must select 1 print design and 1 color scheme from the website. She will also choose 1 fabric: burlap, linen, or silk. How many different possible lampshade designs does she have to choose from?

F. 7
G. 11
H. 12
J. 24
K. 48

39. Which of the following 2-dimensional shapes, when rotated about its vertical symmetry line, will form the shape of this lampshade?

A. Circle
B. Octagon
C. Pentagon
D. Rectangle
E. Isosceles trapezoid

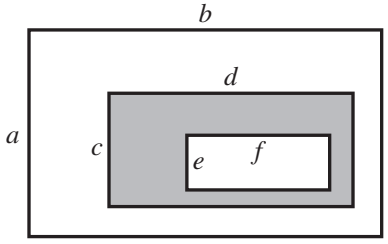
---

40. The points K, L, M, and N are on a number line in that order such that $KM = 15$ units, $LN = 26$ units, and $KN = 32$ units. The coordinate of L is 0, and the coordinate of K is negative. What is the coordinate of M ?

F. 6
G. 9
H. 11
J. 15
K. 17

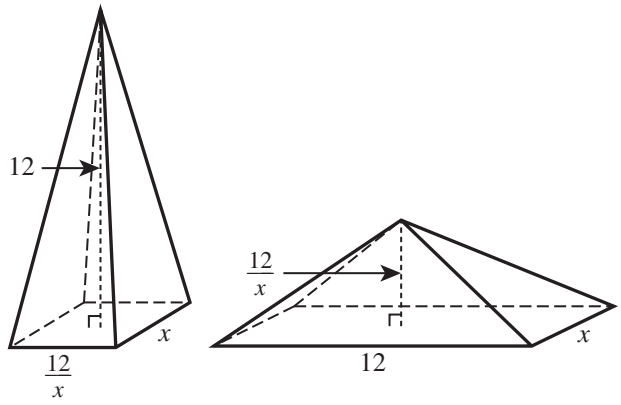
DO YOUR FIGURING HERE.

41. The figure below shows 3 rectangles where a, b, c, d, e, and f are side lengths measured in meters. Which of the following expressions *must* give the area of the shaded region, in square meters?



A. $ab - cd$
B. $ab - ef$
C. $cd - ef$
D. $cd + ef$
E. $ab - cd + ef$

42. Rectangular pyramids A (left) and B (right) are shown below with dimensions given in feet.



A B

Let a and b be the volumes of A and B, respectively. Which of the following equations is true?

F. $a = \frac{1}{3}b$

G. $a = \frac{2}{3}b$

H. $a = b$

J. $a = \frac{3}{2}b$

K. $a = 3b$

43. Maya's digital music library has a total of 249 songs. Her library has 64 songs that are remixes and 85 hip-hop songs. Of the hip-hop songs in her library, 25 are remixes. How many songs in her library are NEITHER remixes NOR hip-hop songs?

A. 75
B. 100
C. 125
D. 139
E. 224

DO YOUR FIGURING HERE.

44. Which of the following expressions is equivalent to $x(x-2)+(2-x)$?

F. $(x+1)(x-2)$
G. $(x+1)(2-x)$
H. $(x-2)(2-x)$
J. $(x-1)(2-x)$
K. $(x-1)(x-2)$

45. For all $a \neq 0$ and $b \neq 0$, the expression $\dfrac{\frac{2}{a}+\frac{2}{b}}{\frac{3}{ab}}$ simplifies to:

A. $\frac{4}{3}$

B. $4(a+b)$

C. $6(a+b)$

D. $\frac{2(a+b)}{3}$

E. $\frac{4ab}{3(a+b)}$

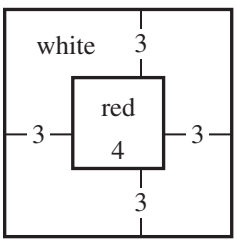
46. In the ordered pairs given below, the first number is time, in hours, and the second number is distance, in miles, traveled in that time.

$A(0.25,1)$, $B(0.2,0.5)$, $C(2,7)$, $D(0.5,8)$, $E(0.75,9)$

Which of these ordered pairs represent speeds less than 4 miles per hour?

F. A and B only
G. B and C only
H. A, B, and C only
J. C, D, and E only
K. A, B, C, D, and E

47. A square dartboard is red and white, as shown below. Each 4-inch-long side of the red square is parallel to 2 sides of the white square and is 3 inches from the closest side of the white square. A dart will be thrown randomly and will land on the dartboard. What is the probability that the dart will land on the red square?



A. $\frac{1}{10}$

B. $\frac{1}{7}$

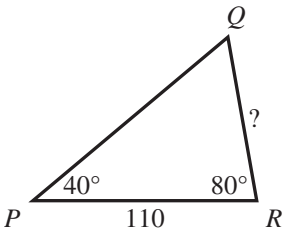
C. $\frac{2}{5}$

D. $\frac{4}{25}$

E. $\frac{16}{49}$

DO YOUR FIGURING HERE.

48. In $\triangle PQR$ shown below, the measure of $\angle P$ is 40°, $PR = 110$ meters, and the measure of $\angle R$ is 80°. Which of the following expressions gives QR, in meters?



(Note: For a triangle with sides of length a, b, and c that are opposite angles $\angle A$, $\angle B$, and $\angle C$, respectively, $\frac{\sin \angle A}{a} = \frac{\sin \angle B}{b} = \frac{\sin \angle C}{c}$.)

F. $\frac{110 \sin 40°}{\sin 60°}$

G. $\frac{110 \sin 40°}{\sin 80°}$

H. $\frac{110 \sin 60°}{\sin 40°}$

J. $\frac{110 \sin 80°}{\sin 40°}$

K. $\frac{110 \sin 80°}{\sin 60°}$

49. $\log_5 25 = ?$

A. $\frac{1}{5}$

B. 2

C. 5

D. 25

E. 5^{25}

50. Let A be the greatest whole number that is less than $\sqrt{420}$. Let B be the least whole number that is greater than $\sqrt{56}$. What is $A - B$?

F. 12
G. 13
H. 14
J. 18
K. 19

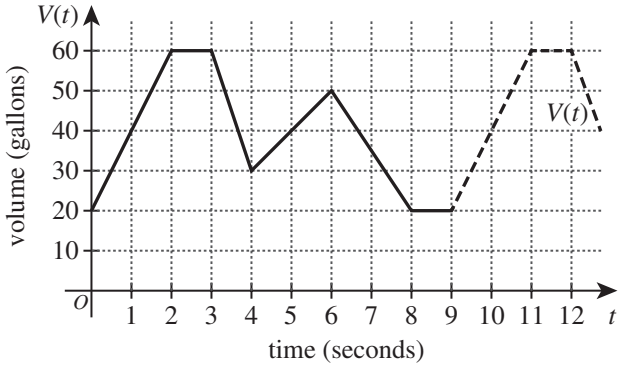
51. The product of 2 real numbers is a nonzero rational number. Which of the following statements CANNOT be true?

A. Both numbers are irrational.
B. Both numbers are rational.
C. Both numbers are integers.
D. One number is positive, and the other is negative.
E. One number is rational, and the other is irrational.

DO YOUR FIGURING HERE.

Use the following information to answer questions 52–54.

A pump is used to move water in and out of a tank. The pump is turned on at $t = 0$ seconds when there are 20 gallons in the tank. The function $V(t)$ represents the volume, in gallons, of water in the tank t seconds after the pump is turned on. Shown below is the graph of $V(t)$, which is a periodic function with a period of 9 seconds. The 1st period of $V(t)$ is shown as a solid line, and the rest is shown as dashed. The pump remains on for 1 hour.



52. How many periods does the pump complete in 1 hour?

F. 6
G. 54
H. 360
J. 400
K. 540

53. One of the following values is the volume, in gallons, of water in the tank after 51 seconds. Which one?

A. 20
B. 30
C. 40
D. 50
E. 60

54. A 2nd tank has 30 gallons in it when its pump is turned on at $t = 0$ seconds. In terms of gallons of water moved over time, this pump behaves the same as the other pump. One of the following functions represents the volume, in gallons, of water in the 2nd tank t seconds after the pump is turned on. Which one?

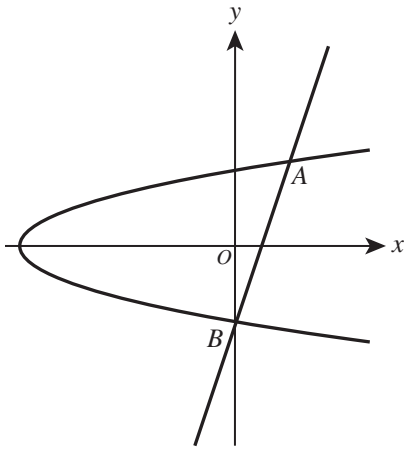
F. $V(t) + 10$
G. $V(t) + 30$
H. $V(t + 10)$
J. $10 \cdot V(t)$
K. $30 \cdot V(t)$

DO YOUR FIGURING HERE.

55. To estimate the number of bass in a small lake, a biology class caught and tagged 32 bass from the lake. The next day the class caught 60 bass from the lake and found that 9 of those bass were tagged. Assuming the 60 bass caught are representative of the entire population of bass in the lake, which of the following is closest to the number of bass in the entire population?

A. 92
B. 101
C. 213
D. 273
E. 327

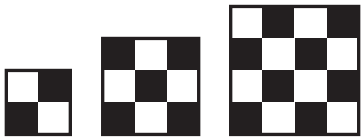
56. The graphs of $y^2 = x + 8$ and $y = 3x - 3$ are shown in the standard (x,y) coordinate plane below. The 2 graphs intersect at points A and B. The solution of which of the following equations gives the x-coordinate of point A ?



F. $\sqrt{3x-3} = -\sqrt{x+8}$
G. $\sqrt{3x-3} = \sqrt{x+8}$
H. $9x^2 - 9 = x + 8$
J. $3x - 3 = -\sqrt{x+8}$
K. $3x - 3 = \sqrt{x+8}$

57. The first 3 elements of a pattern are shown below. Each element is composed of small squares that are 8 mm wide and 8 mm long. Each element after the 1st element is a square that is 8 mm wider and 8 mm longer than the previous element. What is the area, in square *centimeters*, of the 4th element?

A. 16
B. 20
C. 25
D. 40
E. 64



DO YOUR FIGURING HERE.

58. A shirt will be randomly selected from a display of 23 shirts. The probability that the selected shirt will be long-sleeved is $\frac{13}{23}$. The probability that the selected shirt will be white is $\frac{8}{23}$. The probability that the selected shirt will be long-sleeved *and* white is $\frac{3}{23}$. What is the probability that the selected shirt will be long-sleeved *or* white *or* both?

F. $\frac{7}{23}$

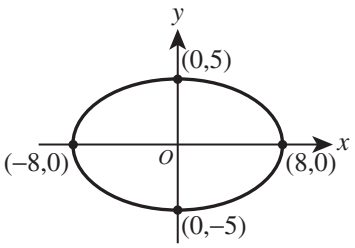
G. $\frac{8}{23}$

H. $\frac{18}{23}$

J. $\frac{22}{23}$

K. $\frac{24}{23}$

59. The ellipse in the standard (x,y) coordinate plane below is centered at the origin. The endpoints of the major and minor axes of the ellipse are labeled. Which of the following equations determines this ellipse?



A. $(x - 8)^2 + (y - 5)^2 = 1$

B. $(x + 8)^2 + (y + 5)^2 = 1$

C. $\frac{x^2}{8} + \frac{y^2}{5} = 1$

D. $\frac{x^2}{16} + \frac{y^2}{10} = 1$

E. $\frac{x^2}{64} + \frac{y^2}{25} = 1$

60. Given $a - b > a + b$ for real numbers a and b, which of the inequalities below *must* be true?

I. $a > 0$
II. $b < 0$
III. $b < a$

F. I only
G. II only
H. I and III only
J. II and III only
K. I, II, and III

END OF TEST 2

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

DO NOT RETURN TO THE PREVIOUS TEST.

READING TEST

35 Minutes—40 Questions

DIRECTIONS: There are several passages in this test. Each passage is accompanied 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.

Passage I

LITERARY NARRATIVE: This passage is from the short story "Pinch Hitter" by Rochelle Spencer.

In the first paragraph, the narrator is reflecting on a story her boyfriend once told her about his father's prize baseball card.

And when he spoke like this, even if I couldn't find the words, I thought I knew exactly what he meant. Whenever he spoke like this, I was convinced that stories were powerful, that they let us reinvent ourselves, that they allowed us to become something stronger and greater than what we are.

But now that I am older, I realize this isn't always the case—stories don't always heal. Today, I make my living as a reporter, and after nearly a decade of interviewing people about their discarded dreams, I recognize that not everyone gains strength from telling their stories. Certainly, this was true of even my own mother and her story of how she'd met Jackie Robinson. She'd told this story hundreds of times over the years for no other reason than she simply enjoyed telling it. She liked to exaggerate all the events leading up to the great occasion except for one: the moment she actually saw Jackie Robinson—that part never changed, never altered, not once.

The summer my mother moved to New York was the same summer Sugar Ray Robinson regained the middleweight title and the Dodgers won the World Series. It was 1955, and to my mother, the entire world seemed accessible. That summer, she arrived from Trinidad accompanied by a hot breeze sprinkled, she claims, with the scent of oranges. And because my mother is one of those people who has been beautiful all of her life, she assumed that sweet breeze was made just for her, to tickle her bronze skin and high cheekbones.

That summer, all of Brooklyn left their windows open. Bed-Stuy was moving from a mostly Jewish-Italian neighborhood to a mostly black one, and the sounds of Sinatra, Ray Charles, and Dodgers announcer Ray Barber drifted from kitchen to street. There were places—libraries, the corners of basements—where you could be cool and alone, but people really talked to you here, and that's how my mother first developed this whole idea of accessibility, this feeling that she could wrap her arms around the world. In fact, my mother says that one of the first things that happened to her when she first came to New York was that she saw, in a way so accidental it felt like magic, Jackie Robinson on the subway after a game.

In those days, my mother and her brother Richard would go into the city to meet their father, who worked two jobs, after he finished his first shift as a janitor at one of the local department stores. During those slips of time, they'd go out for ice cream, play chess, listen to the Dodgers game on the radio. My mother, Malinda Lee, was young enough where these moments still seemed precious to her, but Richard had discovered girls, and they consumed his thoughts. And perhaps that's why Richard failed to notice the group of people—chattering disparate threads woven together only by a famous baseball player—while my mother saw nothing else.

So my mother, curious, ran up to a man on the outskirts of the crowd and asked who was at its center.

The man only half-turned, his eyes fixed on the greatness in front of him. "That, sweetheart, is Jackie Robinson."

At that moment, Malinda Lee caught a glimpse of Robinson, saw the soft sky blue of his uniform. And somehow, through that throng, Robinson turned and held her stare. Then Robinson, my mother swears, reached through that enormous crowd and shook her hand. Robinson gave my mother's hand a squeeze—a warm, rushed gesture my mother later described as the only real handshake she has ever known. But as soon as their palms touch, four police officers came and, acting as bodyguards, escorted Robinson through the station. Still, for the rest of her life, my mother would talk about the feel of that handshake. She would say it had made her feel important, like she too was someone who mattered, like she too was someone who could change things.

Now on the rare times when my mother and I were actually getting along, when we were out working in the garden and the sweat and the dirt and the sunshine made us feel a little more free with each other, she'd retell this story. She'd embellish, of course, but still I

loved to hear her speak, loved to hear her voice skip and swing like a game of Double-Dutch. And when she was done, she'd sigh, shake her head, run her fingertips across her beautiful, sculpted face. "There's a difference," she'd murmur with a somberness that always surprised me, "between celebrities and heroes." And then I, unused to my mother demonstrating any genuine feeling, would try to think of something sarcastic to say, and would only be able to nod my head.

1. In the passage, lines 20–77 can most nearly be described as reflecting the perspective of:

- **A.** a young girl recalling the moment her mother met Jackie Robinson.
- **B.** a young girl recounting an exciting moment during her first summer in New York.
- **C.** an adult woman telling her daughter about an important moment in her life.
- **D.** an adult woman telling a story she has heard many times.

2. Based on the passage, compared to how the narrator once felt about the power of stories, she now feels:

- **F.** more certain that people often embellish the stories they tell.
- **G.** more certain that people use stories to reinvent themselves.
- **H.** less certain that people gain strength from telling stories.
- **J.** less certain that people tell stories to help others heal.

3. The statement "that part never changed, never altered, not once" (lines 18–19) most nearly serves to:

- **A.** emphasize that the unchanged part of the mother's story was dull compared to the embellished parts.
- **B.** highlight the significance of the unchanged part of the mother's story and give it credibility.
- **C.** provide evidence of the mother's commitment to keeping the details of her stories consistent.
- **D.** distinguish between stories that the mother told truthfully and stories that she lied about.

4. One main purpose of the third paragraph (lines 20–30) is to:

- **F.** indicate that Malinda Lee felt special because she saw both Sugar Ray Robinson and the Dodgers win titles right after she arrived in New York.
- **G.** convey the optimism that Malinda Lee felt during the summer of 1955.
- **H.** establish that while Malinda Lee was excited to experience New York, she didn't want to forget Trinidad.
- **J.** depict what Malinda Lee saw on the streets of New York in 1955.

5. According to the passage, when Malinda Lee noticed the crowd of people surrounding Robinson, her brother was most likely:

- **A.** playing chess with their father.
- **B.** listening to the Dodgers on the radio.
- **C.** still exiting the stadium.
- **D.** thinking about girls.

6. According to the passage, when Robinson shook her hand, the narrator's mother felt:

- **F.** proud that the onlookers knew she mattered.
- **G.** that he was too rushed to really see her.
- **H.** restricted by the enormous crowd.
- **J.** that she could change things.

7. Based on the last paragraph, how does the experience of sharing the story about Robinson affect the relationship between the narrator and her mother?

- **A.** It deepens the narrator's love of their playful and productive relationship.
- **B.** It intensifies the mother's sadness about not being the narrator's hero.
- **C.** It reinforces the narrator's contempt for her dramatic and difficult mother.
- **D.** It invites genuine feeling into their relatively strained relationship.

8. In the last paragraph, the narrator's descriptions of her mother's voice most strongly suggest that her mother:

- **F.** tells the story energetically and then becomes solemn and introspective afterward.
- **G.** finds that telling her story about the moment she met Robinson puts her in a playful mood.
- **H.** nearly sings while telling her story but becomes sarcastic after she's done.
- **J.** performs her story as if she were onstage and then is disappointed that her daughter isn't impressed.

9. The metaphor used in lines 55–56 to describe the people surrounding Robinson most strongly suggests that the people:

- **A.** were a group of friends who were congratulating Robinson after watching the baseball game.
- **B.** had little in common beyond their appreciation for Robinson.
- **C.** shared interwoven lives within a close-knit neighborhood.
- **D.** often gathered to discuss their favorite baseball players.

10. As it is used in line 81, the word *free* most nearly means:

- **F.** independent.
- **G.** immodest.
- **H.** discrete.
- **J.** relaxed.

Passage II

SOCIAL SCIENCE: This passage is from the article "Built to Last" by Nikhil Swaminathan.

The Romans started building with concrete regularly beginning in the third century B.C., but the earliest uses go back roughly a thousand years further, to ancient Greece. Concrete is made of chunks of rubble held together by mortar. Today, mortar is typically made by mixing gravel, sand, and binders such as lime and cement. According to Marie Jackson, a research engineer at the University of California, Berkeley, and ROMACONS (Roman Maritime Concrete Study) collaborator, modern concrete begins to break apart underwater. The material used by the Romans for maritime construction, however, actually gets stronger over time.

In the first century B.C., the architect and engineer Vitruvius wrote an expansive work on Roman building methods called *De Architectura*. In it, he describes a substance found near Baia, a resort town on the Bay of Naples, and around Mount Vesuvius, that "when mixed with lime and rubble, not only lends strength to buildings of other kinds, but even when piers of it are constructed in the sea, they set hard under water."

The ROMACONS team set out to confirm what Vitruvius had written by studying the concrete used to build harbors dotting the Mediterranean, including Caesarea, Portus (one of Rome's great harbors), Pompeiopolis in modern-day Turkey, and Hersonissos in northern Crete. The researchers took cores, measuring four inches in diameter and up to 20 feet long, from various parts of each harbor, many of which are now submerged.

Jackson was then enlisted to investigate the concrete's physical characteristics and material makeup. She found that its compressive strength, meaning the weight it can bear, was much lower than that of modern concrete, so it wasn't suitable for tall aboveground architecture. When she compared the trace elemental composition of the mortars in the cores, however, she confirmed Vitruvius' assertion. All the samples contained volcanic ash that came either from Mount Vesuvius or Campi Flegrei, volcanoes located east and west of Naples, respectively. The same ash was also found in a sample sent to the team from Quarteira on the coast of southern Portugal.

The specific type of ash is known as pozzolana after Pozzuoli, the town near Campi Flegrei where it was originally used, but John Oleson, a classical archaeologist at the University of Victoria in British Columbia, says you can find it throughout the Bay of Naples. "If you're rowing a boat along the coast near Baia, parts of the coastline are made up of this pozzolana," he explains.

Jackson credits the Romans with noticing that, over time, the ash consolidated into a volcanic rock called tuff. With that insight they formulated their unique mortar recipe: pozzolana, lime, and seawater. That mixture, which she says must have been arrived at by careful experimentation, results in the growth of a durable binding substance throughout the concrete mixture. "Pliny the Elder says that they needed something that lasts a long time and gets stronger with age," Jackson explains, quoting the ancient Roman scholar and natural historian. Because seawater is part of the reaction, placing this mortar in the Mediterranean promotes greater adhesion rather than causing the concrete to crack.

According to Oleson, the Romans relied on the pozzolana for maritime construction for two centuries, beginning about 40 B.C. He suggests that its presence in ports as far east as Caesarea and Alexandria shows that the ash was exported throughout the empire from the Bay of Naples.

"ROMACONS has managed to document the evolution of this [maritime concrete] industry and the type of materials used, and to document the trade across the Mediterranean, a trade that previously was not known," Oleson explains. He posits that, for example, a grain ship arriving in Rome's Portus from Alexandria might have been sent back with pozzolana stored in sacks for ballast, which would then be used in port construction back east.

The reactivity of Bay of Naples pozzolana was well known in antiquity, says Lynne Lancaster, a classics professor at Ohio University. She has documented shorter-range trade within the Roman Empire in her research, including the export of lightweight volcanic rocks from Sardinia for use in building vaults in Carthage. What the ROMACONS project has identified, Lancaster says, "is a Mediterranean-wide trade that is being used to build the ports, which in turn is used to increase the trade. This contributes more to the economics and infrastructure of the Roman Empire."

11. The main purpose of the passage is to:

- **A.** show how the ROMACONS research helped improve the composition of modern concrete.
- **B.** describe the composition and origin of pozzolana.
- **C.** compare modern concrete to Roman maritime concrete.
- **D.** provide an overview of the ROMACONS project and its findings.

12. Based on the passage, the statement that Roman maritime concrete gets stronger over time can best be categorized as:

- **F.** a fact supported by Jackson's analysis of Roman maritime concrete's physical characteristics and material makeup.
- **G.** a fact that the passage author presents as a result of his own research on Roman maritime concrete.
- **H.** an opinion of Jackson's that has yet to be tested by the ROMACONS team.
- **J.** an opinion of the passage author's that is supported by Oleson's and Jackson's remarks about Roman maritime concrete.

13. According to the passage, both typical modern mortar and the mortar used to create Roman maritime concrete may contain:

- **A.** seawater.
- **B.** lime.
- **C.** tuff.
- **D.** cement.

14. Based on the passage, the study conducted by Jackson and the ROMACONS team was directly inspired by:

- **F.** Vitruvius's *De Architectura*.
- **G.** Pliny the Elder's historical notes.
- **H.** Oleson's discovery of pozzolana.
- **J.** Lancaster's research in ancient vault-building.

15. It can reasonably be inferred that the "cores" (line 26) mentioned in the passage most directly refer to:

- **A.** rock produced from volcanic ash.
- **B.** volcanic ash that came from Mount Vesuvius or Campi Flegrei.
- **C.** samples of concrete from harbors built in the Mediterranean.
- **D.** chunks of concrete collected from the ruins of ancient Greek houses.

16. The main point of the eighth paragraph (lines 71–79) is that, by documenting aspects of the maritime concrete industry, the ROMACONS project has helped reveal:

- **F.** proof that the Roman civilization invented concrete.
- **G.** the presence of pozzolana along the coast near Baia.
- **H.** new information about Roman trade across the Mediterranean.
- **J.** evidence that the Romans built ports throughout the Bay of Naples.

17. According to the passage, Roman maritime concrete's lower compressive strength makes the concrete:

- **A.** unsuitable for use in tall, aboveground architecture.
- **B.** relatively easy to transport.
- **C.** unable to withstand the pressure of being submerged in deep water.
- **D.** time-consuming to produce.

18. Based on the passage, the Romans formulated their unique mortar recipe after observing that pozzolana:

- **F.** could be found on the coast of southern Portugal.
- **G.** consolidated into volcanic rock over time.
- **H.** binds easily to gravel.
- **J.** was used in port construction throughout the Bay of Naples.

19. According to the passage, Jackson believes that the Romans' process of formulating their unique mortar recipe involved:

- **A.** specialized training.
- **B.** sheer luck.
- **C.** careful experimentation.
- **D.** unfortunate accidents.

20. Which of the following pieces of evidence does Oleson use to support the idea that the ash used in Roman maritime concrete was exported throughout the empire?

- **F.** The ash was found in ports in Caesarea and Alexandria.
- **G.** The ash was named for Pozzuoli, the town where it was originally used.
- **H.** The ash makes up parts of the coastline throughout the Bay of Naples.
- **J.** The ash had been used for port construction in Greece.

Passage III

HUMANITIES: Passage A is from the article "In Plain Sight" by Virginia Campbell. Passage B is from the article "Jennifer McChristian: A Journey of Evolving Vision and Ability" by Allison Malafronte.

"Plein air" refers to the act of painting in outdoor daylight.

Passage A by Virginia Campbell

Jennifer McChristian sees and feels Los Angeles light with the sensitivity of the original California plein-air painters, but she is very much a modern, urban artist. Like earlier painters of city scenes, such as Edward Hopper or artists of the Ashcan School, she is possessed of an eye that finds interest in places that would be written off as ordinary or ugly by those attuned to more conventionally compelling or beautiful scenes.

"I like mundane-ness," says McChristian. "I don't feel that I need to travel to find something to paint. I'm confident that anywhere I go, I can find a painting. Anything is worth painting. I'm impartial. I love any kind of subject matter."

A small oil on panel titled *In Between* makes the artist's point. The painting creates visual poetry out of the dappled light in a narrow, overlooked space between two city houses. We can imagine that these houses have front and back yards to which some degree of attention has been paid, but this green space is more of a no-man's land where an old charcoal grill and pieces of gutter are stashed. The geometry of this neglected world is eased up as the lines of perspective are interrupted with bright splashes of green and slanting blue shadows.

McChristian's contention that anything is worth painting is argued even more forcefully in another small oil on panel, *Santa Fe Ave.*, which shows a marginal slice of Los Angeles. This is one of those places you end up when your online directions turn out to be wrong. It is the kind of indefinable space that seldom makes its way onto canvas, but McChristian has reaped a harvest of curiosity out of it. A traffic cone, utility poles, what looks like a factory in the background, all framed by the underbelly of a bridge. The empty street, with no cars to be seen, suggests activity that has been inexplicably suspended.

"I like the post-apocalyptic feel of the deserted street. I loved the traffic cone not just for the dash of color but because it implies the activity of working, but it's not going on right now. I prefer places that aren't well known because I want people to have the feeling that they've been there without their actually having been there. I want them to make the painting their own," she says. "It's always a composition that makes me stop the car and get out and really look," she adds. Once out of the car, the artist sees the place's true potential.

Passage B by Allison Malafronte

Jennifer McChristian's style is a dynamic combination of traditional impressionism with contemporary subject matter, inspired by her travels and observations of the world. When talking about her style, she mentions the contrast between her earlier work and her current work, which is more expressive and narrative in nature—a sure sign that she is continuing to evolve as an artist and reach a new level of ability, confidence, and understanding.

Like many painters from the Los Angeles area, McChristian began her career in commercial art, cutting her teeth as an animator and learning drawing and design skills that would serve her future fine-art work well. "When I was working in animation, it was predominantly a traditional medium," McChristian recalls. "Computers were only just beginning to infiltrate the industry, and every story element still had to be designed and drawn by hand. By consistently drawing, I was sharpening my hand-eye coordination, judging proportions, and regularly exercising the creative side of my brain. Drawing on a regular basis is guaranteed to strengthen your painting skills and is a necessary foundation for representational art."

When it comes to subject matter, McChristian is drawn to both traditional plein air motifs—including the deserts, mountains, and coastal seascapes of California—and more urban cityscapes, European street scenes, and interiors, which often include figurative elements and suggestive storylines. In addition to her evolving stylistic approach, McChristian's motivation for painting has also changed over the years, and with that her paint handling and thought process. "When I first entered the fine-art world, I was intent on creating detailed, representational depictions," she says. "Now I find myself simplifying to focus on the core essence of my subject, concentrating more on the feelings evoked from a subtle combination of nostalgia and suggestive elements. As I've continued to grow, I've been playing with the idea of becoming more abstract, saying more with less. I've also become more engaged spiritually, analytically, and emotionally with the process of painting."

Questions 21–24 ask about Passage A.

21. The main purpose of the third paragraph of Passage A (lines 15–25) is to:

- **A.** emphasize that McChristian's art features unusual geometry and colors.
- **B.** provide an example of a specific painting that inspired McChristian's work.
- **C.** establish that McChristian has changed her approach to paintings.
- **D.** underscore that McChristian's subject matter is often mundane.

22. Based on Passage A, the space depicted in *In Between* can best be described as:

- **F.** mostly neglected with a few discarded objects in it.
- **G.** vibrantly green with trees and a well-tended garden.
- **H.** narrow and filled with objects that suggest that it is frequently used.
- **J.** mostly overgrown with no indication that people live nearby.

23. According to Passage A, McChristian is similar to the original California plein air painters in the way that she:

- **A.** considers herself a modern, urban artist.
- **B.** sees and feels Los Angeles light.
- **C.** paints scenes found in downtown Los Angeles.
- **D.** selects and arranges objects in her paintings.

24. Passage A indicates that because McChristian wants her viewers to make her paintings their own, she prefers to create paintings of places that:

- **F.** make people feel as if they have been to the place in the painting although they likely have not.
- **G.** are well-known, such as famous beaches and roadways.
- **H.** are unfamiliar and cause people to feel distanced from the subject matter.
- **J.** have not been painted before, so people feel as if they are having a new experience.

Questions 25–27 ask about Passage B.

25. In Passage B, the main idea of the second paragraph (lines 58–71) is that McChristian's experience in animation:

- **A.** occurred just as computers were infiltrating the industry.
- **B.** taught her that painting is harder than drawing.
- **C.** inspired her to use computers in her later works.
- **D.** helped her hone her painting skills.

26. Based on Passage B, compared to McChristian's paintings from when she first entered the fine art world, her later paintings have been more focused on:

- **F.** realistic depictions of a subject.
- **G.** the core essence of a subject.
- **H.** portraying human interaction.
- **J.** traditional subject matter.

27. As it is used in line 61, the word *serve* most nearly means:

- **A.** provide.
- **B.** suffice.
- **C.** attend.
- **D.** aid.

Questions 28–30 ask about both passages.

28. Which of the following statements best reflects the difference between the main purposes of the passages?

- **F.** Passage A discusses McChristian's unusual subject matter, whereas Passage B primarily discusses how her painting has developed.
- **G.** Passage A focuses on the differences between two of McChristian's paintings, whereas Passage B contends that her art is becoming more abstract.
- **H.** Passage A argues that McChristian's art is undervalued, whereas Passage B explains how drawing affected her paintings.
- **J.** Passage A describes the appeal of McChristian's paintings, whereas Passage B discusses the artists that influenced her work.

29. The passages are similar in that they both make use of:

- **A.** quotations from art critics describing McChristian's style.
- **B.** quotations from McChristian regarding her paintings.
- **C.** detailed descriptions of landscape paintings by McChristian.
- **D.** comparisons between McChristian's commercial art and her fine art.

30. Based on the passages, which of the following statements best describes the relationship between McChristian's art and travels?

- **F.** McChristian doesn't need to travel to find something to paint, but travel has inspired her paintings.
- **G.** McChristian can find a subject to paint anywhere, but most of her paintings are set in places far from her home.
- **H.** McChristian prefers to travel outside the United States to paint, but most of her art portrays scenes near Los Angeles.
- **J.** McChristian usually paints scenes near Los Angeles, but she painted her most famous works while visiting Europe.

Passage IV

NATURAL SCIENCE: This passage is from *Seven Elements That Changed the World*: *An Adventure of Ingenuity and Discovery* by John Browne.

In the late 1940s, William Shockley and his team in the solid state physics group at Bell Labs were exploring the unusual electrical properties of a group of elements called semiconductors. Bell's telephone networks were still operated using mechanical switches and signals were amplified using vacuum tubes. These were slow and unreliable and so the director of research was tasked with finding an electronic alternative. Shockley thought the answer could be found in semiconductors, from which he hoped to create an amplifying and switching device. Although its theoretical basis seemed flawless, it did not work. His colleague John Bardeen, a brilliant theoretical physicist, then set his mind to the problem. He realised that electrons were becoming trapped at the surface of the semiconductor, stopping current flowing through the device. Working with Walter Brattain, whose skilled hands matched and complemented Bardeen's brain, Bardeen was able to overcome the surface trapping and, in doing so, turned Shockley's idea into a practical reality, the world's first transistor.

At the end of June 1948, Bell Labs announced the invention of the transistor by Shockley, Bardeen and Brattain; they would later win the Nobel Prize in Physics for this breakthrough. At the press conference, they explained that the transistor had the potential to replace the vacuum tube, the device then used to make radios and rudimentary computers. Like the vacuum tube, the transistor could amplify electrical signals and act as an on-off switch, but do so much faster, in a much smaller volume, using much less power. At the time, the media thought all this unimportant and made little fuss. The *New York Times* 'carried the big news on page 46, buried at the end of a column of radio chitchat.' The potential for the transistor to change the world had yet to be realised by the wider public. After all, journalists must have wondered, what impact could these devices and their abstract functions have on our everyday lives? Even today, few people make a connection between these minute pieces of silicon and the complex functioning of the computers, with which we create images, manage communications and generate sounds.

Any computational problem can be broken down into a set of simple logical steps, such as the decision to combine two numbers or choose one or the other. These steps are controlled by 'logic gates', which are the basic building blocks of digital circuits. Logic gates are made from transistors and other simple components, and they use transistors as switches to send signals. Most logic gates have two on-off switches which together act as inputs. Each switch can either be off or on, known as '0' or '1', and the logic gate's output is determined by these two inputs as well as the type of logic gate. For example, an 'AND' gate will give an output of 1 only if both the first 'and' second inputs are 1. All other input combinations (0 and 1; 1 and 0; 0 and 0) will result in an output of 0. A computer, at a fundamental level, is simply a number of these transistor-based logic gates linked together to produce a complex output. The capability and complexity of the computer rises as more and more gates are connected.

Transistors allow this to happen because they are very small, very cheap and use only a little power. Those features allow enormous numbers of them to be put together in one computer. It is, however, their speed that makes computers really useful. A transistor's on-off switching function is controlled by a small electric current. Its small size and the speed of the electrons enable it to be turned on and off well over 100 billion times each second. If you used your finger, it would take around 2,000 years to turn a light switch on and off as many times. Silicon's semiconducting properties make it ideal for making these switches, although other semiconductors, such as germanium, were originally used and today transistors can be made of many different alloys. None of them, however, rival silicon's combination of high performance and low cost.

The first commercial applications of the transistor were not, however, computers, but technologies that used its other function as an amplifier. The first of these was a hearing aid produced by Sonotone in 1952. The same principle was applied in radios, amplifying the electromagnetic waves received from transmitting stations. The small size of the transistor dramatically reduced the size and cost of radios, making them portable and opening up their ownership to a vast new market.

31. The main purpose of the passage is to:

- **A.** argue that the structural features of the transistor became a model for later inventions.
- **B.** discuss the unintended consequences that resulted from the invention of the transistor.
- **C.** describe the invention of the transistor and its significance.
- **D.** analyze the processes that allow a transistor to work.

32. In the second paragraph (lines 22–43), which of the following does the author use to support his claim that the media found the invention of the transistor unimportant?

- **F.** Comments from journalists who questioned the importance of transistors
- **G.** A description of the press conference following the presentation of the Nobel Prize in Physics
- **H.** Claims about the minimal radio coverage of the invention of transistors
- **J.** Information regarding the placement of a news item about transistors in the *New York Times*

33. The passage indicates that, compared to transistors, vacuum tubes and mechanical switches:

- **A.** require fewer repairs.
- **B.** rely more on semiconductors.
- **C.** are more effective for amplification.
- **D.** work less quickly.

34. The main idea of the last paragraph is that:

- **F.** hearing aids were the first products sold that used transistors.
- **G.** radios continue to be the product most associated with transistors.
- **H.** amplification was the first commercial application of transistors.
- **J.** computer designers were hesitant at first to make use of transistors.

35. The passage indicates that one role Bardeen played in the early development of the transistor was to:

- **A.** identify why the semiconductor wasn't performing properly.
- **B.** suggest replacing vacuum tubes with semiconductors.
- **C.** convince Shockley that the theoretical basis of his plan was flawed.
- **D.** persuade Shockley to bring Walter Brattain into the project.

36. Which of the following statements is the best paraphrase for the author's point in lines 39–43?

- **F.** Currently, many people exhibit an overdependence on technology.
- **G.** At present, most people do not appreciate the full impact of transistors.
- **H.** The vulnerability of technology today is due to its overreliance on transistors.
- **J.** Since the invention of transistors, journalists have made significant progress in their understanding of technology.

37. According to the passage, what is the relationship between transistors and logic gates?

- **A.** Transistors were replaced by logic gates.
- **B.** Logic gates use electricity generated by transistors.
- **C.** Logic gates are made in part from transistors.
- **D.** Transistors are made up of a series of logic gates.

38. According to the passage, transistors' size, cost, and power requirements are significant because these qualities:

- **F.** demonstrate the accuracy of the predictions of Shockley and his team.
- **G.** vindicate the proponents of silicon semiconductors.
- **H.** compensate for the relatively low speed of transistors' switching functions.
- **J.** allow a large number of interconnected transistors to be contained in one computer.

39. The author refers to the manual operation of a light switch (lines 71–73) mainly to emphasize the:

- **A.** small amount of electric power that transistors require to function.
- **B.** high speed at which transistors can be turned on and off.
- **C.** resistance of many people to the changes brought on by transistors.
- **D.** speed at which transistors became integrated into many technologies.

40. According to the passage, the fact that transistors allowed radios to be made smaller and less expensively resulted in a:

- **F.** wider recognition of the importance of transistors.
- **G.** change in radio programming to appeal to new audiences.
- **H.** significant increase in the number of potential radio buyers.
- **J.** similar process being adopted in the manufacturing of hearing aids.

END OF TEST 3

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

DO NOT RETURN TO A 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

Radon (Rn) is a naturally occurring radioactive gas. Scientists conducted a study to measure the Rn concentration in *soil gas* (the gases present between soil particles) following a major earthquake that occurred in May 2008.

Study

In June 2008, 8 sites (Sites 1–8) were selected along the fault line of the earthquake. Site 1 was approximately 25 km to the northeast from the epicenter of the earthquake, and each successive site was 25 km to 50 km farther to the northeast than the previous site. The vertical displacement of the ground due to the earthquake was measured at each site (see Figure 1).

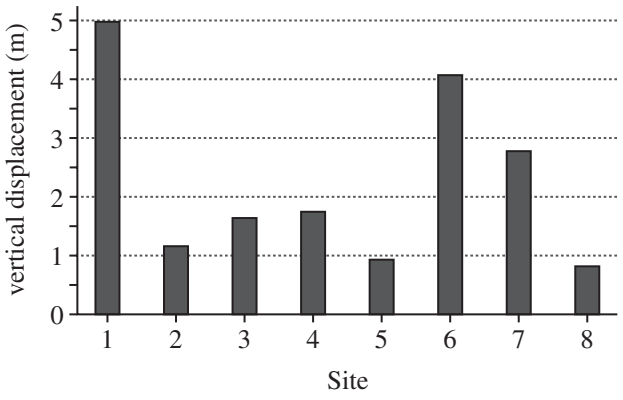


Figure 1

At each site, 4 pairs of 2.3 cm diameter holes were drilled 0.80 m deep in the soil. A rigid Teflon tube was placed in each hole and then covered with an airtight cap fitted with a length of flexible tubing (see Figure 2).

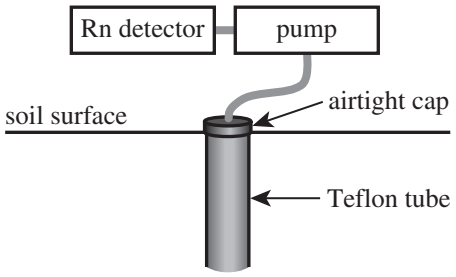


Figure 2

At each hole, the soil gas was pumped out of the tube and into an Rn detector at a flow rate of 1 L/min. Three successive readings were taken with the Rn detector, each lasting 5 min, and the average Rn concentration, in kilobecquerels per cubic meter (kBq/m^3), was determined. At each of the holes, the Rn measurements were repeated in December 2008 and again in July 2009. Figure 3 shows the average Rn concentration at each of the 8 sites on each of the 3 dates that readings were taken.

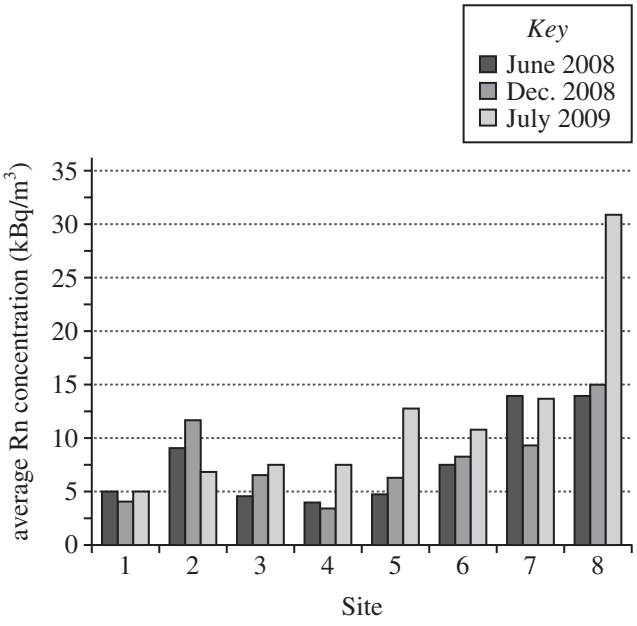


Figure 3

1. According to Figure 3, the average Rn concentration in June 2008 at Site 3 was closest in value to the average Rn concentration in July 2009 at which of the following sites?

A. Site 1
B. Site 4
C. Site 5
D. Site 8

2. Which of the following expressions best shows the direction of the flow of soil gas through the apparatus shown in Figure 2 ?

F. Teflon tube → pump → Rn detector
G. Teflon tube → Rn detector → pump
H. Pump → Rn detector → Teflon tube
J. Pump → Teflon tube → Rn detector

3. Consider the site having the second-largest vertical displacement in Figure 1. According to Figure 3, the average Rn concentration at that site in December 2008 was approximately:

A. 4 kBq/m^3.
B. 8 kBq/m^3.
C. 12 kBq/m^3.
D. 16 kBq/m^3.

4. Based on Figure 3, the average Rn concentration increased between June 2008 and December 2008 at how many of the sites?

F. 3
G. 4
H. 5
J. 6

5. Which of the following statements best summarizes the December 2008 data for Sites 4–8 ? As distance from the epicenter increased, average Rn concentration:

A. increased only.
B. decreased only.
C. increased, then decreased.
D. decreased, then increased.

6. Based on the description of the sites, what was the minimum possible distance along the fault line between Site 1 and Site 5 ?

F. 25 km
G. 75 km
H. 100 km
J. 175 km

7. Assume that for each Teflon tube, the top of the tube was 1 cm above the surface of the soil and the other end of the tube was at the bottom of the hole. What was the length, in *centimeters*, of each tube?

A. 79 cm
B. 80 cm
C. 81 cm
D. Cannot be determined from the given information

Passage II

The speed of a projectile can be estimated with the use of a *ballistic pendulum*. A ballistic pendulum consists of a block of wood suspended from a string. A projectile strikes the block and becomes embedded in it. As a result, the block swings upward, reaching a maximum height, h, which depends on the mass of the block, M, the mass of the projectile, m, and the speed of the projectile at impact, v (see Figure 1).

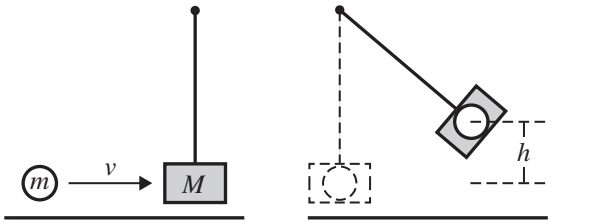


Figure 1

In each of 12 trials, a projectile impacted with a block, h was measured, and v was then calculated (see Table 1).

Table 1

Trial	M (kg)	m (kg)	h (m)	v (m/s)
1	1.00	0.010	0.0050	32
2	1.00	0.010	0.010	45
3	1.00	0.010	0.015	55
4	1.00	0.010	0.020	63
5	1.00	0.020	0.020	32
6	1.00	0.030	0.020	21
7	1.00	0.040	0.020	16
8	1.00	0.050	0.020	13
9	1.10	0.020	0.020	35
10	1.20	0.020	0.020	38
11	1.30	0.020	0.020	41
12	1.40	0.020	0.020	44

8. Based on Trials 1–4, as v increased, h:

F. increased only.
G. decreased only.
H. increased and then decreased.
J. decreased and then increased.

9. What was the absolute value of the difference between the projectile's speed in Trial 1 and the projectile's speed in Trial 10 ?

A. 2 m/s
B. 6 m/s
C. 8 m/s
D. 10 m/s

10. Suppose that a trial had been performed in which M was 1.00 kg and m was 0.060 kg. If the resulting value of h were 0.020 m, v would most likely have been closest to which of the following?

F. 6 m/s
G. 10 m/s
H. 16 m/s
J. 20 m/s

11. What was the independent variable in Trials 9–12 ?

A. M
B. m
C. h
D. v

12. The maximum gravitational potential energy, GPE, of the wooden block containing the projectile is given by the equation:

$$GPE = (M + m) \times g \times h$$

where g is the acceleration due to gravity at Earth's surface. For which trial was GPE greatest?

F. Trial 4
G. Trial 6
H. Trial 8
J. Trial 12

13. In Trial 1, what was M in *grams* ?

A. 1.00
B. 10.0
C. 100
D. 1,000

Passage III

Saturn's moons are classified into groups. Groups 1–4 have a total of 46 moons. Each moon's orbit can be described by its *inclination angle*, i, its *semimajor axis*, a, and its *eccentricity*, e, as illustrated in the 3 panels of Figure 1.

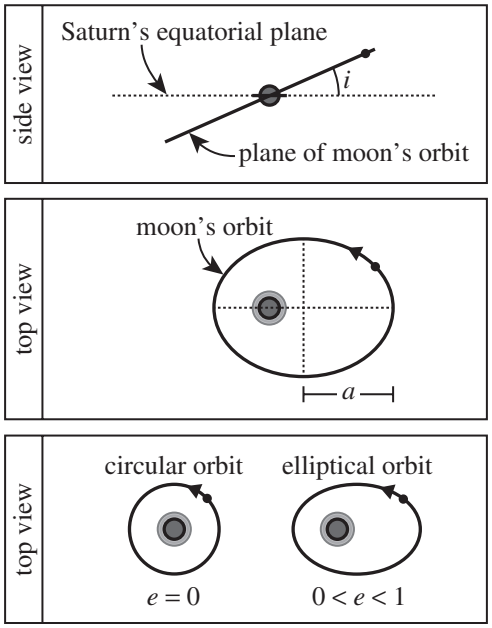


Figure 1

In Figures 2 and 3, i and e, respectively, are plotted against a for each of the 46 moons in Groups 1–4. Moons with positive i orbit Saturn counterclockwise; moons with negative i orbit Saturn clockwise.

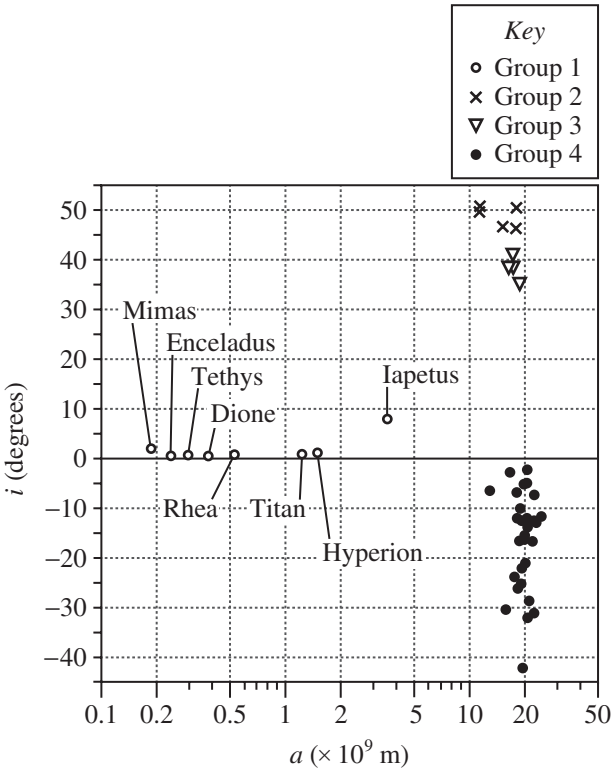


Figure 2

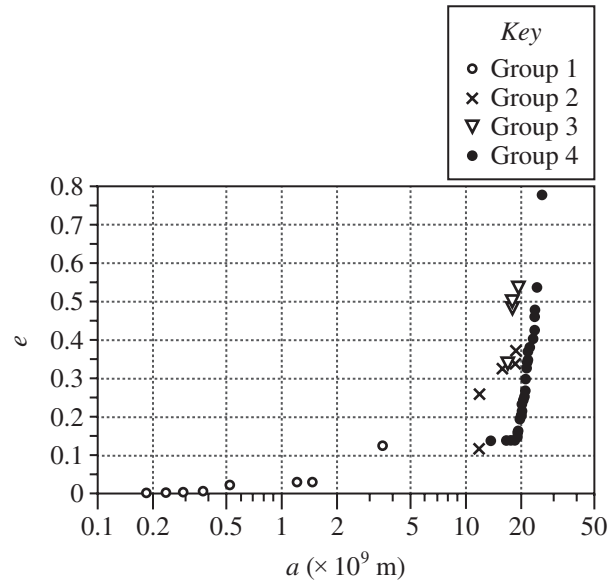


Figure 3

In Figure 4, the *orbital energy* (the sum of a moon's kinetic energy and its gravitational potential energy relative to Saturn), in joules (J), is shown for each of the 46 moons in Groups 1–4.

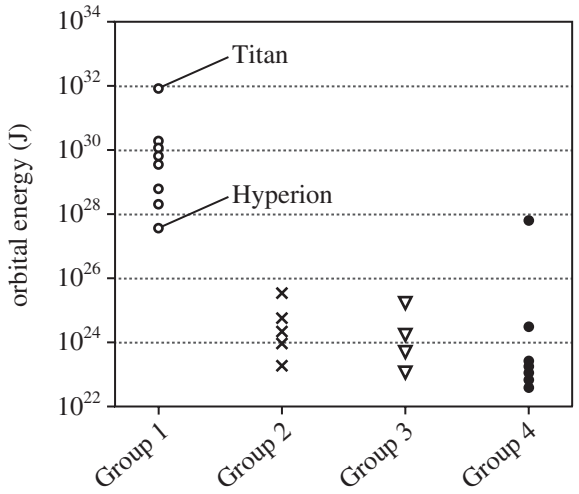


Figure 4

14. For which of the following moons is the semimajor axis closest to 1 billion meters?

F. Enceladus
G. Dione
H. Titan
J. Iapetus

15. Based on Figures 1 and 3, the majority of the moons in Groups 1–4 have orbits that are which shape: circular or elliptical?

A. Circular, because most of the plotted moons have an orbit for which $e = 0$.
B. Circular, because most of the plotted moons have an orbit for which $0 < e < 1$.
C. Elliptical, because most of the plotted moons have an orbit for which $e = 0$.
D. Elliptical, because most of the plotted moons have an orbit for which $0 < e < 1$.

16. There is a Group 4 moon with an orbital energy more similar to those of Group 1 moons than to those of the other Group 4 moons. What is the approximate orbital energy of this moon?

F. 10^{26} J
G. 10^{28} J
H. 10^{30} J
J. 10^{32} J

17. Based on Figures 2 and 3, for which of the ranges listed below are there *no* moons plotted?

I. i between +10° and +30°
II. a between 5×10^9 m and 10×10^9 m
III. e between 0.5 and 0.7

A. II only
B. III only
C. I and II only
D. I, II, and III

18. Based on Figures 2 and 4, each moon that has an inclination angle greater than +30° has an orbital energy that is within which of the following ranges of values?

F. 10^{22} J to 10^{24} J
G. 10^{22} J to 10^{26} J
H. 10^{24} J to 10^{26} J
J. 10^{24} J to 10^{28} J

19. Suppose a new moon is discovered in orbit around Saturn and it is classified as a Group 3 moon. Based on Figure 3, which of the following pairs of values for a and e, respectively, most likely corresponds to the orbit of this moon?

	a (m)	e
A.	11×10^9	0.15
B.	11×10^9	0.45
C.	17×10^9	0.15
D.	17×10^9	0.45

Passage IV

The horseshoe bat *Rhinolophus mehelyi* emits calls and uses the reflected sound waves for a variety of purposes, including determining orientation, detecting food, and communicating. Two studies were done to examine call frequency and mate choice in *R. mehelyi*.

Study 1

Ninety *R. mehelyi* were collected from a single cave. A recording of each bat's call was made when the bat was stationary. Each call was analyzed with an ultrasound detector to determine its *peak frequency* (the frequency at which the call is the loudest). Then the mass of each bat was determined and plotted versus its peak frequency, in kilohertz (kHz). Figure 1 shows the best-fit line obtained from that plot.

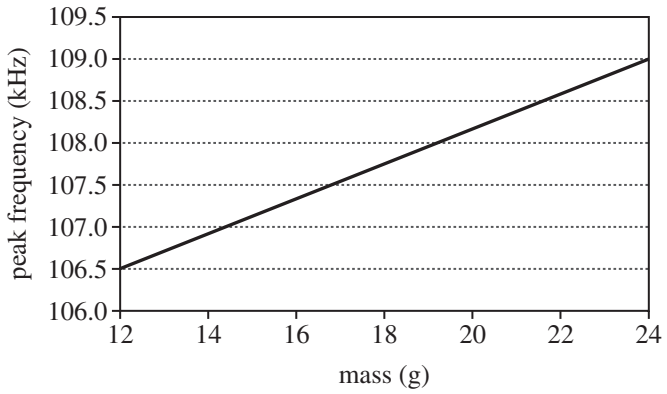


Figure 1

Study 2

A 1 m^3 box was divided into 2 equal compartments, each containing a speaker. A female *R. mehelyi* was placed on a listening perch in the box at a position equidistant from each speaker (see Figure 2).

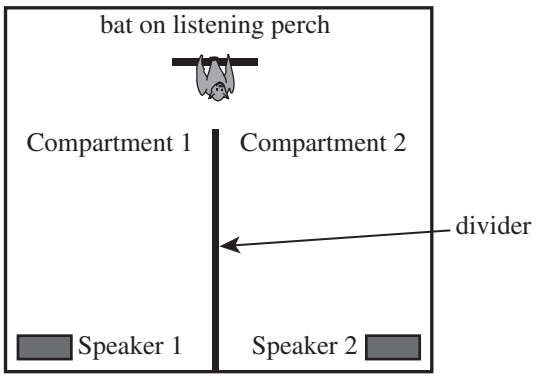


Figure 2

Figures 1 and 2 adapted from Sebastien J. Puechmaille et al., "Female Mate Choice Can Drive the Evolution of High Frequency Echolocation in Bats: A Case Study with *Rhinolophus mehelyi*." ©2014 by PLOS ONE.

In each of 12 trials with the female bat, a male *R. mehelyi* call having a low peak frequency (104 kHz) was played from one speaker and a male *R. mehelyi* call having a high peak frequency (112 kHz) was played from the other speaker. The peak frequencies of the recordings were adjusted to have the same volume. The bat was free to fly within the box. If the bat landed, the compartment in which the bat landed was recorded. For each trial, the calls (low or high peak frequency) were randomly assigned to the speakers. These procedures were repeated with 60 additional female *R. mehelyi*. The results are listed in Table 1.

Table 1

Total bat landings in the compartment that played a:	
low peak frequency call	high peak frequency call
225	460

20. Which of the following statements was most likely the hypothesis for Study 2 ?

- **F.** Males choose mates on the basis of the peak frequency of the potential mates' calls.
- **G.** Males choose mates on the basis of the loudness of the potential mates' calls.
- **H.** Females choose mates on the basis of the peak frequency of the potential mates' calls.
- **J.** Females choose mates on the basis of the loudness of the potential mates' calls.

21. Suppose that the reproductive fitness of male *R. mehelyi* increases as the male attracts more females. Which of the following statements regarding peak frequency and reproductive fitness is consistent with the results of Study 2 ? Male *R. mehelyi* that emit calls with a peak frequency of:

- **A.** 104 kHz are more likely to attract more females and have lower reproductive fitness than are male *R. mehelyi* that emit calls with a peak frequency of 112 kHz.
- **B.** 104 kHz are more likely to attract more females and have higher reproductive fitness than are male *R. mehelyi* that emit calls with a peak frequency of 112 kHz.
- **C.** 112 kHz are more likely to attract more females and have lower reproductive fitness than are male *R. mehelyi* that emit calls with a peak frequency of 104 kHz.
- **D.** 112 kHz are more likely to attract more females and have higher reproductive fitness than are male *R. mehelyi* that emit calls with a peak frequency of 104 kHz.

22. Consider the design of Study 2. Which of the following procedures was most likely done to eliminate preference based on the direction the call came from?

F. The calls were played at different volumes.
G. The calls were randomly assigned to the speakers.
H. Only female *R. mehelyi* calls were played.
J. Only male *R. mehelyi* calls were played.

23. Based on Table 1, the total number of bat landings in the compartment that played a call with a peak frequency of 104 kHz was approximately how many times as great as the total number of bat landings in the compartment that played a call with a peak frequency of 112 kHz ?

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. 2
D. 4

24. Based on the description and the results of Study 2, which of the following expressions shows how to calculate the number of times a female *R. mehelyi* did NOT land in one of the compartments?

F. $(2 \times 61) + (225 + 460)$
G. $(2 \times 61) - (225 + 460)$
H. $(12 \times 61) + (225 + 460)$
J. $(12 \times 61) - (225 + 460)$

25. In Study 1, which of the following procedures was likely performed to ensure that a given peak frequency measurement was not influenced by the Doppler effect?

A. Measuring the mass of each bat
B. Collecting bats from a single cave
C. Placing the bat equidistant from 2 speakers
D. Recording bats while they were stationary

26. For humans, the audible range of sound is 20–20,000 Hertz (Hz). Based on Figure 1, would a human likely be able to hear a call emitted at a peak frequency from a 24 g *R. mehelyi* ?

F. Yes; 107 kHz is in the audible range of sound for humans.
G. Yes; 109 kHz is in the audible range of sound for humans.
H. No; 107 kHz is not in the audible range of sound for humans.
J. No; 109 kHz is not in the audible range of sound for humans.

Passage V

An experiment was performed to determine the concentrations of each of 7 metal ions—lead (Pb^{2+}), cadmium (Cd^{2+}), zinc (Zn^{2+}), iron (Fe^{2+}), manganese (Mn^{2+}), copper (Cu^{2+}), and nickel (Ni^{2+})—in 4 varieties of mushrooms (Varieties W–Z). The concentration of each ion was determined using an *atomic absorption spectrometer* (AAS).

In the AAS, a solution containing a mixture of metal ions is slowly misted into a flame. Then, for each type of metal to be analyzed, a beam of light—having a particular wavelength unique to that type of metal—is passed through the flame onto a detector (see Figure 1). Any light that is absorbed by the metal in the flame does not reach the detector. Thus, for a given type of metal, the fraction of light absorbed (the *absorbance*) is directly proportional to the concentration of that metal ion in solution.

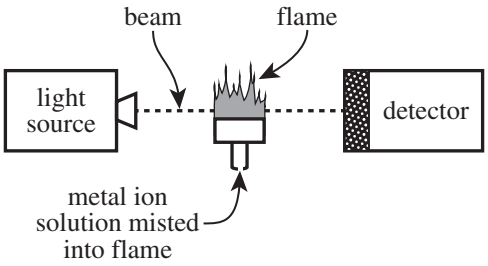


Figure 1

Experiment

For each mushroom variety, Steps 1–5 were performed:

1. A 0.500 g sample of dried mushrooms was collected.
2. A 20.0 mL volume of nitric acid was added to the sample, and then it was stirred at 65°C until the sample completely dissolved.
3. The solution was cooled to 25°C, and pure H_2O was added until the total solution volume was 50.0 mL.
4. A 10.0 mL portion of this solution was then misted into the flame.
5. The absorbance was measured for each metal, and the concentration of each metal ion in the sample was then calculated in milligrams of metal ion per kilogram of mushrooms (mg/kg).

The results are shown in Table 1.

Table 1

Variety	Concentration (mg/kg) of:						
	Pb^{2+}	Cd^{2+}	Zn^{2+}	Fe^{2+}	Mn^{2+}	Cu^{2+}	Ni^{2+}
W	4.7	1.8	109	1,890	102	49.5	30.1
X	3.3	1.7	47.5	270	30.5	37.5	8.1
Y	2.5	27.2	87.5	926	43.5	96.5	2.5
Z	3.4	1.3	47.5	265	30.0	35.5	6.6

Table 1 adapted from J. MacNeil, et al. "Mushroom Magic: Analysis of Metals in a Familiar Food." ©2012 by Division of Chemical Education, Inc., American Chemical Society.

27. Suppose that, before the experiment, a scientist had predicted that Variety X mushrooms would have a greater concentration of Mn^{2+} than Variety Y mushrooms. Are the results of the experiment consistent with this prediction?

A. No; the concentration of Mn^{2+} was 30.5 mg/kg for Variety X and 43.5 mg/kg for Variety Y.
B. No; the concentration of Mn^{2+} was 37.5 mg/kg for Variety X and 96.5 mg/kg for Variety Y.
C. Yes; the concentration of Mn^{2+} was 43.5 mg/kg for Variety X and 30.5 mg/kg for Variety Y.
D. Yes; the concentration of Mn^{2+} was 96.5 mg/kg for Variety X and 37.5 mg/kg for Variety Y.

28. Based on the results of the experiment, which mushroom variety more likely had the higher measured absorbance for zinc: Variety W or Variety Y ?

F. Variety W; a higher concentration corresponds to a higher absorbance.
G. Variety W; a lower concentration corresponds to a higher absorbance.
H. Variety Y; a higher concentration corresponds to a higher absorbance.
J. Variety Y; a lower concentration corresponds to a higher absorbance.

29. Suppose that 0.25 g of dried Variety W mushrooms were mixed with 0.25 g of dried Variety X mushrooms and tested using the procedures of the experiment. Based on Table 1, the concentration of copper in this mixture would most likely have been:

A. less than 37.5 mg/kg.
B. between 37.5 mg/kg and 49.5 mg/kg.
C. between 49.5 mg/kg and 96.5 mg/kg.
D. greater than 96.5 mg/kg.

30. Was the pH of the liquid added to the mushrooms in Step 2 more likely less than 7.0 or greater than 7.0 ?

F. Less than 7.0; the liquid was an acid.
G. Less than 7.0; the liquid was a base.
H. Greater than 7.0; the liquid was an acid.
J. Greater than 7.0; the liquid was a base.

31. Based on the description of the AAS, how many different wavelengths of light were passed through the flame when each of the mushroom varieties was tested?

A. 1
B. 4
C. 7
D. 28

32. Based on the description of the AAS, the detector directly measured the:

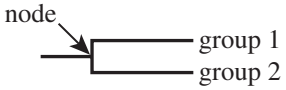
F. volume of nitric acid in solution.
G. mass of dried mushrooms in the flame.
H. concentration of metal ions in solution.
J. light that passed through the flame.

33. Consider the cadmium ion as shown in Table 1. When this ion is formed from a neutral cadmium atom, does the number of protons increase or stay the same, and does the number of electrons increase or decrease?

	protons	electrons
A.	increase	increase
B.	increase	decrease
C.	stay the same	increase
D.	stay the same	decrease

Passage VI

A *phylogenetic tree* shows proposed patterns of descent among groups of organisms. Each *node* (branching point) represents the *most recent common ancestor* (MRCA) of the 2 descendant groups (see the diagram). Groups that are more closely related share a more recent MRCA than do groups that are less closely related.



Three students each analyzed a different type of molecular data—DNA sequence, *protein sequence* (order of amino acids), or RNA sequence—to determine if turtles share a more recent MRCA with *archosaurs* (birds and crocodiles) or with *squamates* (lizards and snakes). Each of the students constructed a phylogenetic tree based on his or her analysis.

Student 1

The length of a particular DNA sequence varies among groups of organisms. As species evolve, new DNA subunits are added. An analysis of DNA sequences from turtles, archosaurs, and squamates indicates that turtles and archosaurs share the greatest number of additions. Therefore, turtles and archosaurs share a more recent MRCA than do turtles and squamates (see Figure 1).

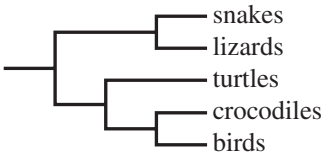


Figure 1

Student 2

The length of a particular protein sequence remains the same among groups of organisms. As species evolve, some amino acids are substituted by different amino acids. An analysis of protein sequences from turtles, archosaurs, and squamates indicates that turtles and crocodiles share the greatest number of substitutions. Therefore, turtles and crocodiles share a more recent MRCA than do either turtles and birds, or turtles and squamates (see Figure 2).

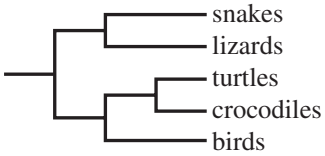


Figure 2

Student 3

The length of a particular RNA sequence varies among groups of organisms. As species evolve, some RNA subunits are deleted. An analysis of RNA sequences from turtles, archosaurs, and squamates indicates that turtles and squamates share the greatest number of deletions. Therefore, turtles and squamates share a more recent MRCA than do turtles and archosaurs (see Figure 3).

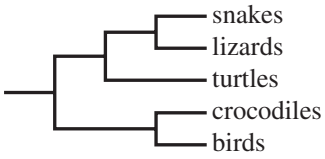


Figure 3

Figures adapted from Naoyuki Iwabe, et al., "Sister Group Relationship of Turtles to the Bird-Crocodilian Clade Revealed by Nuclear DNA–Coded Proteins." ©2004 by Society for Molecular Biology and Evolution.

34. Which of the following statements regarding the MRCAs of snakes is consistent with the phylogenetic trees of all 3 students? Snakes share a more recent MRCA with:

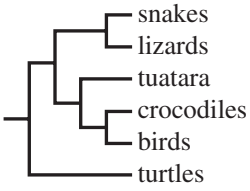
F. birds than with the other groups of organisms.
G. turtles than with the other groups of organisms.
H. lizards than with the other groups of organisms.
J. crocodiles than with the other groups of organisms.

35. The phylogenetic tree constructed by which of the students supports the hypothesis that turtles are more closely related to archosaurs than to squamates?

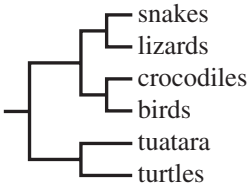
A. Student 2 only
B. Student 3 only
C. Students 1 and 2 only
D. Students 1 and 3 only

36. *Tuatara* (a reptile native to New Zealand) share a more recent MRCA with squamates than with archosaurs. Which of the following proposed phylogenetic trees is most consistent with this information?

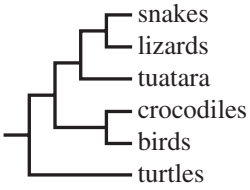
F.



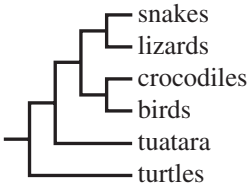
H.



G.



J.



37. Suppose that the length of a horizontal line segment from a group of organisms to its nearest node is directly proportional to the length of time that group of organisms has existed. Based on this information, how many of the phylogenetic trees, if any, suggest that turtles have existed for a longer length of time than have birds?

A. 0
B. 1
C. 2
D. 3

38. Student 3's phylogenetic tree includes how many common ancestors of turtles and birds?

F. 1
G. 2
H. 3
J. 4

39. An amino acid can be abbreviated by a single letter. Suppose that, for a certain protein, an ancestor has the amino acid sequence DVLDSL and a descendant group has the sequence KVNDSL. Were these sequences more likely analyzed by Student 2 or by Student 3, and how many substitutions are present in the descendant group?

	Student	Substitutions
A.	2	2
B.	2	4
C.	3	2
D.	3	4

40. Which of the students analyzed sequences of nucleic acids?

F. Student 2 only
G. Student 3 only
H. Students 1 and 2 only
J. Students 1 and 3 only

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.

Scoring Guide

Raw Scores

The number of questions you answered correctly on each test section is a raw score. Because there are many forms of the ACT, each with different questions, the difficulty level varies between the forms. A raw score of 35 on one form of the mathematics test section, for example, may be about as difficult to earn as a raw score of 37 on another form of that test section.

Computing raw scores: To compute your raw scores, check your answers with the scoring information in the scoring keys and conversion table and do the following:

1. Mark a one (1) in the blank for each question answered correctly.
2. Count the number of correct answers for each of the four multiple-choice test sections.
3. Add up the total number correct for each category and test section and capture it as directed above its scoring key.

These numbers are your raw scores on the individual multiple-choice test sections. The highest raw score for a given test section is the number of questions included on that test section:

- English: 75
- Mathematics: 60
- Reading: 40
- Science: 40

Note: *Raw scores are also provided as part of the Summary Report for each test section taken online in TestNav.*

English Test 1 Section

English Scoring Key *(for Form G20)*

English Reporting Categories
(Capture raw scores/correct answers.)

Production of Writing (POW) = ___ of 23

Knowledge of Language (KLA) = ___ of 12

Conventions of Standard English (CSE) = ___ of 40

Total English (POW + KLA + CSE) = ___ of 75

English Number	Correct Answer	Correct (Mark 1)	Reporting Categories
1	A		CSE
2	G		POW
3	D		CSE
4	J		CSE
5	C		KLA
6	G		CSE
7	A		CSE
8	H		KLA
9	A		CSE
10	H		KLA
11	D		CSE
12	F		CSE
13	B		POW
14	H		CSE
15	D		POW
16	J		CSE
17	B		POW
18	F		KLA
19	C		KLA
20	J		CSE
21	A		POW
22	J		CSE
23	C		CSE
24	F		CSE
25	A		POW

English Number	Correct Answer	Correct (Mark 1)	Reporting Categories
26	J		CSE
27	B		POW
28	J		KLA
29	A		CSE
30	F		POW
31	D		POW
32	J		CSE
33	A		CSE
34	H		CSE
35	B		KLA
36	G		KLA
37	C		CSE
38	J		CSE
39	D		CSE
40	G		POW
41	B		POW
42	F		CSE
43	A		CSE
44	F		POW
45	C		POW
46	G		CSE
47	B		POW
48	H		POW
49	A		POW
50	H		CSE

English Number	Correct Answer	Correct (Mark 1)	Reporting Categories
51	C		POW
52	G		KLA
53	A		CSE
54	J		POW
55	B		CSE
56	H		CSE
57	D		CSE
58	H		KLA
59	B		CSE
60	G		POW
61	D		CSE
62	G		CSE
63	D		CSE
64	F		CSE
65	C		POW
66	G		CSE
67	D		KLA
68	F		KLA
69	A		CSE
70	J		CSE
71	A		CSE
72	H		CSE
73	D		POW
74	J		POW
75	C		POW

Mathematics Test 2 Section

Mathematics Scoring Key *(for Form G20)*

Mathematics Reporting Categories
(Capture raw scores/correct answers.)

Preparing for Higher Math (PHM) = ___ of 35
(A + F + G + N + S)
A = Algebra
F = Functions
G = Geometry
N = Number & Quantity
S = Statistics & Probability

Integrating Essential Skills (IES) = ___ of 25

Modeling (MDL) = ___ of 27

Total Mathematics (PHM + IES) = ___ of 60

Note: *Do not include MDL in Total Mathematics raw score.*

Math Number	Correct Answer	Correct (Mark 1)	Reporting Categories
1	C		PHM-A
2	J		IES
3	E		PHM-N
4	H		IES, MDL
5	E		PHM-A
6	H		IES, MDL
7	D		PHM-F
8	F		IES
9	D		IES
10	G		PHM-S, MDL
11	E		IES, MDL
12	F		PHM-A, MDL
13	B		IES
14	H		IES, MDL
15	C		PHM-G
16	G		IES
17	D		PHM-G
18	G		PHM-N
19	D		PHM-G, MDL
20	K		IES, MDL
21	D		PHM-F
22	J		PHM-N
23	D		PHM-A
24	G		PHM-A, MDL
25	D		IES, MDL
26	H		PHM-F
27	B		IES
28	H		IES
29	C		IES, MDL
30	K		PHM-G, MDL
31	E		IES, MDL
32	F		PHM-G
33	B		PHM-F
34	G		IES
35	E		PHM-F
36	F		PHM-S, MDL
37	C		IES
38	K		PHM-S, MDL
39	E		PHM-G, MDL
40	G		IES
41	C		IES
42	H		IES, MDL
43	C		PHM-S, MDL
44	K		PHM-A
45	D		PHM-A, MDL
46	G		IES, MDL
47	D		IES
48	F		PHM-G
49	B		PHM-F
50	F		PHM-N, MDL
51	E		PHM-N
52	J		IES, MDL
53	D		PHM-F, MDL
54	F		PHM-F, MDL
55	C		PHM-S, MDL
56	K		PHM-A
57	A		IES, MDL
58	H		PHM-S, MDL
59	E		PHM-G
60	G		IES

Reading Test 3 Section

Reading Scoring Key *(for Form G20)*

Reading Reporting Categories
(Capture raw scores/correct answers.)

Key Ideas & Details (KID) = ___ of 24

Craft & Structure (CS) = ___ of 10

Integration of Knowledge & Ideas (IKI) = ___ of 6

Total Reading (KID + CS + IKI) = ___ of 40

Reading Number	Correct Answer	Correct (Mark 1)	Reporting Categories
1	D		CS
2	H		KID
3	B		CS
4	G		CS
5	D		KID
6	J		KID
7	D		KID
8	F		KID
9	B		CS
10	J		CS
11	D		CS
12	F		IKI
13	B		KID
14	F		KID
15	C		KID
16	H		KID
17	A		KID
18	G		KID
19	C		KID
20	F		IKI
21	D		CS
22	F		KID
23	B		KID
24	F		KID
25	D		KID
26	G		KID
27	D		CS
28	F		IKI
29	B		IKI
30	F		IKI
31	C		CS
32	J		IKI
33	D		KID
34	H		KID
35	A		KID
36	G		KID
37	C		KID
38	J		KID
39	B		CS
40	H		KID

Science Test 4 Section

Science Scoring Key *(for Form G20)*

Science Reporting Categories
(Capture raw scores/correct answers.)

Interpretation of Data (IOD) = ___ of 18

Scientific Investigation (SIN)= ___ of 12

Evaluation of Models, Inferences
& Experimental Results (EMI) = ___ of 10

Total Science (IOD + SIN + EMI) = ___ of 40

Science Number	Correct Answer	Correct (Mark 1)	Reporting Categories
1	A		IOD
2	F		SIN
3	B		IOD
4	H		IOD
5	A		IOD
6	H		SIN
7	C		SIN
8	F		IOD
9	B		IOD
10	G		IOD
11	A		SIN
12	J		IOD
13	D		IOD
14	H		IOD
15	D		IOD
16	G		IOD
17	C		IOD
18	G		IOD
19	D		IOD
20	H		SIN
21	D		EMI
22	G		SIN
23	B		IOD
24	J		SIN
25	D		SIN
26	J		IOD
27	A		EMI
28	F		EMI
29	B		SIN
30	F		SIN
31	C		SIN
32	J		SIN
33	D		IOD
34	H		EMI
35	C		EMI
36	G		EMI
37	C		EMI
38	F		EMI
39	A		EMI
40	J		EMI

Scale Scores

To adjust for the small differences among different forms of the ACT test, raw scores are converted into scale scores. Scale scores appear on reports sent to your school.

When your raw scores are converted into scale scores, it becomes possible to compare your scores with those of examinees who took different test forms. For example, a scale score of 26 on the mathematics test section has the same meaning for any form of the ACT.

Converting Raw Scores to Scale Scores

Each ACT test section generates a single scale score of 1–36. Use the Conversion of Raw Scores to Scale Scores table to convert your raw scores to scale scores. For each test section:

1. Locate your raw score, or the range of raw scores that includes it, in the conversion table.
2. Locate the cell in the Scale Score column of the row that corresponds to that raw score to identify the scale score for that test section.
3. As you determine your scale scores, enter them in the blanks below.

Test section scale scores:

English = ___

Mathematics = ___

Reading = ___

Science = ___

Calculating a Composite Score

An ACT test generates a single Composite score of 1–36. Compute the Composite score by averaging the four scale scores. To do this:

1. Add your four scale scores. Enter this sum of scores in the blank below.
2. Divide the sum by 4. If the resulting number ends in a fraction, round it to the nearest whole number. (Round down any fraction less than one-half, except for averages lower than one; round up any fraction that is one-half or more and/or less than one.)
3. Enter this number in the blank below. This is your Composite score.

Composite of scale scores:

Sum of scores = ___

Composite score (sum ÷ 4) = ___

Note: *If you left a test section completely blank and marked no items, do not list a scale score for that section and do not calculate a Composite score.*

Conversion of Raw Scores to Scale Scores *(for Form G20)*

Scale Score	Raw Score Test 1: English	Raw Score Test 2: Mathematics	Raw Score Test 3: Reading	Raw Score Test 4: Science
36	74–75	60	39–40	40
35	72–73	58–59	38	39
34	71	57	—	38
33	70	56	37	37
32	69	55	36	36
31	68	53–54	35	35
30	67	51–52	34	34
29	66	50	33	—
28	65	48–49	32	33
27	64	45–47	31	32
26	62–63	42–44	30	30–31
25	60–61	39–41	29	29
24	57–59	37–38	28	26–28
23	54–56	35–36	26–27	24–25
22	51–53	33–34	24–25	22–23
21	48–50	32	22–23	21
20	45–47	30–31	21	19–20
19	43–44	28–29	20	17–18
18	41–42	25–27	19	16
17	39–40	22–24	17–18	14–15
16	36–38	18–21	16	13
15	33–35	15–17	15	12
14	29–32	11–14	13–14	11
13	26–28	9–10	12	10
12	24–25	7–8	10–11	9
11	20–23	6	8–9	8
10	16–19	5	7	7
9	14–15	4	6	6
8	12–13	3	5	5
7	10–11	—	—	4
6	8–9	2	4	3
5	6–7	—	3	—
4	5	1	2	2
3	3–4	—	—	1
2	2	—	1	—
1	0–1	0	0	0

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