Question 1

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-APR.3: Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.

A function is shown.

\[ f(x) = x^2 + 2x - 48 \]

One of the zeros of the function is \( x = 6 \).

What is the other zero of the function?

Scoring Rubric:

1 point
For this item, the response correctly
• identifies either \(-8\) or \( x = -8 \).
Sample Correct Answer:

A function is shown.
\[ f(x) = x^2 + 2x - 48 \]
One of the zeros of the function is \( x = 6 \).
What is the other zero of the function?

\[ x = -8 \]

Explanation of Correct Answer:

The zeros of a function are the points where \( f(x) = 0 \). To reveal the zeros of the function, factor the polynomial as shown.

\[
\begin{align*}
f(x) &= x^2 + 2x - 48 \\
0 &= x^2 + 2x - 48 \\
0 &= x^2 + (8 - 6)x + (8 \cdot -6) \\
0 &= (x + 8)(x - 6)
\end{align*}
\]

Thus, the zeros of the function are \( x = 6 \) and \( x = -8 \). Since \( x = 6 \) is given, the correct answer for the other zero is \( x = -8 \).
Question 2

**Reporting Category:** Algebraic Concepts & Procedures

**Common Core Standard:** A-REI.3: Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

An inequality is shown.

\[ 5 - 7x < 33 \]

Move an arrow onto the number line to show the correct solution to the inequality.

**Scoring Rubric:**

1 point
For this item, the response correctly
- places the open arrow facing to the right, with the open circle on -4.
Sample Correct Answer:

An inequality is shown.

\[ 5 - 7x < 33 \]

Move an arrow onto the number line to show the correct solution to the inequality.

---

Explanation of Correct Answer:

The solution to the inequality is an interval on the number line. The inequality \( 5 - 7x < 33 \) can be solved using the following steps.

\[
\begin{align*}
5 - 7x &< 33 \\
-7x &< 28 \\
x &> -4
\end{align*}
\]

(The symbol is > because both sides are divided by -7.)

The answer indicates the correct interval is \( x > -4 \). The arrow should show an open interval because the inequality does not include values equal to -4.
Question 3

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-REI.4a: Solve quadratic equations in one variable. a. Use the method of completing the square to transform any quadratic equation in \( x \) into an equation of the form \( (x - p)^2 = q \) that has the same solutions. Derive the quadratic formula from this form.

An equation is shown.

\[ x^2 + 8x + 19 = 0 \]

What is an equivalent equation that results from completing the square?

Scoring Rubric:

1 point
For this item, the response correctly
• identifies an equivalent equation.
Sample Correct Answer:

An equation is shown.

\[ x^2 + 8x + 19 = 0 \]

What is an equivalent equation that results from completing the square?

\[(x+4)^2 = -3\]

Sequence of Keypad Clicks to Enter the Answer:

(), x, +, 4, →, □□, 2, =, −, 3

Explanation of Correct Answer:

The steps to complete the square are shown.

\[ x^2 + 8x + 19 = 0 \]
\[ x^2 + 8x = -19 \]
\[ x^2 + 8x + \left(\frac{8}{2}\right)^2 = -19 + \left(\frac{8}{2}\right)^2 \]
\[ x^2 + 8x + 16 = -19 + 16 \]
\[ (x + 4)^2 = -3 \]
Question 4

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-REI.6: Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

A system of equations is shown.

\[ y = x + 2 \]
\[ y = -2x - 1 \]

A. Use the Add Arrow tool to graph the two equations.

B. What is the solution to the system of equations?

Drag numbers to the boxes to show the solution.

Scoring Rubric:

1 point
For this item, the response correctly
• draws the two lines and identifies the coordinates of the solution.
Sample Correct Answer:

A system of equations is shown.

\[ y = x + 2 \]
\[ y = -2x - 1 \]

A. Use the Add Arrow tool to graph the two equations.

B. What is the solution to the system of equations?

Drag numbers to the boxes to show the solution.

![Graph of two lines intersecting at (-1, 1)]

**Explanation of Correct Answer:**

Since both equations are in slope-intercept form, use the \( y \)-intercept and slope to graph each equation. For the first equation, the \( y \)-intercept is 2. From that point, use the slope of \( \frac{1}{1} \) to arrive at \((1, -3)\). The graph of \( y = x + 2 \) is the line through the points \((0, 2)\) and \((1, 3)\).

For the second equation, the \( y \)-intercept is -1. From that point, use the slope of \( -2 \) \( \left( -2 \right) \) to arrive at \((1, -3)\). The graph of \( y = -2x - 1 \) is the line through \((0, -1)\) and \((1, -3)\).

Finally, the solution of the system can be found by determining the intersection point of the two lines. This intersection occurs at the coordinates \((-1, 1)\).
Question 5

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: F-IF.7a: Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. a. Graph linear and quadratic functions and show intercepts, maxima, and minima.

Answer Key: A

A function has an x-intercept at (4, 0) and a y-intercept at (0, −12).

Which graph could represent the function?

A.

![Graph A](image)

This answer is correct. The student recognized that the given intercepts were on the graph.

B.

![Graph B](image)

This answer is not correct. The student may have treated the y-intercept as a second x-intercept.
C. This answer is not correct. The student may have treated the x-intercept as the slope.

D. This answer is not correct. The student may have reversed the x- and y-intercepts.
Question 6

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-REI.4b: Solve quadratic equations in one variable. b. Solve quadratic equations by inspection (e.g. for x^2 = 49), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a + bi$ for real numbers $a$ and $b$.

Solve the equation shown.

$x^2 + 4x = 12$

Enter each solution on a separate line.

Scoring Rubric:

1 point
For this item, the response correctly
• identifies both solutions.
Sample Correct Answer:

Solve the equation shown.

\[ x^2 + 4x = 12 \]

Enter each solution on a separate line.

\[ -6 \]

\[ 2 \]

Explanation of Correct Answer:

To solve the equation, first put it in factored form using the steps shown.

\[ x^2 + 4x = 12 \]
\[ x^2 + 4x - 12 = 0 \]
\[ x^2 - 2x + 6x - 12 = 0 \]
\[ x(x - 2) + 6(x - 2) = 0 \]
\[ (x + 6)(x - 2) = 0 \]

Then use the zero product property to determine the solutions \( x = -6 \) and \( x = 2 \).
Question 7

**Reporting Category:** Algebraic Concepts & Procedures

**Common Core Standard:** A-SSE.3a: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. a. Factor a quadratic expression to reveal the zeros of the function it defines.

A quadratic equation is shown.

\[ x^2 - 6x - 72 = 0 \]

What is the factored form of the quadratic equation?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>9</td>
<td>&lt;</td>
</tr>
<tr>
<td>0</td>
<td>-</td>
<td>0</td>
<td>( )</td>
</tr>
</tbody>
</table>

**Scoring Rubric:**

1 point

For this item, the response correctly

- identifies an equivalent equation.
Sample Correct Answer:

A quadratic equation is shown.

\[ x^2 - 6x - 72 = 0 \]

What is the factored form of the quadratic equation?

\[ (x-12)(x+6) = 0 \]

Explanation of Correct Answer:

The steps to factor the equation are shown.

\[
\begin{align*}
x^2 - 6x - 72 &= 0 \\
x^2 + (-12 + 6)x + (-12 \cdot 6) &= 0 \\
(x - 12)(x + 6) &= 0
\end{align*}
\]

Sequence of Keypad Clicks to Enter the Answer:

\[ (), x, -, 12, \rightarrow(), x, +, 6, \rightarrow., =, 0 \]
Question 8

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-CED.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law \( V = IR \) to highlight resistance \( R \).

The formula that can be used to determine the speed of a wave pulse traveling along a string or wire is shown.

\[ T = \frac{m v^2}{L} \]

Write an equation that shows the given formula solved for \( v \).

Scoring Rubric:

1 point
For this item, the response correctly
- identifies an equivalent equation.
Sample Correct Answer:

The formula that can be used to determine the speed of a wave pulse traveling along a string or wire is shown.

\[ T = \frac{m v^2}{L} \]

Write an equation that shows the given formula solved for \( v \).

\[ v = \sqrt{\frac{TL}{m}} \]

Sequence of Keypad Clicks to Enter the Answer:

\[ V, =, \sqrt[\ldots]{\ldots}, T, L, \text{ click on the denominator, } m, \rightarrow, \]

Explanation of Correct Answer:

The steps to solve the equation for \( v \) are shown.

\[
\begin{align*}
T &= \frac{m v^2}{L} \\
LT &= m v^2 \\
\frac{LT}{m} &= v^2 \\
\pm \sqrt{\frac{LT}{m}} &= v
\end{align*}
\]

Then, since the speed must be positive, a correct equation for the formula solved for \( v \) is \( v = \sqrt{\frac{LT}{m}} \).
Question 9

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-REI.1: Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

Answer Key: B

Meredith is solving the equation $7x + 3(x - 2) = 14$.

Her first step is shown as $7x + 3x - 6 = 14$.

Which statement best describes Meredith's work in her first step?

A. She combined the terms 3 and $x$.

   This answer is not correct. The student may have thought only the 3 and $x$ terms were combined instead of applying the distributive property.

B. She distributed 3 to the terms in the parentheses.

   This answer is correct. The student used the distributive property to get from $3(x - 2)$ to $3x - 6$.

C. She combined like terms by adding them together.

   This answer is not correct. The student may have confused the distributive property with combining like terms.

D. She removed parentheses in order to isolate the variable.

   This answer is not correct. The student may have thought the terms were regrouped using the associative property.
Question 10

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-REI.11: Explain why the x-coordinates of the points where the graphs of the equations \( y = f(x) \) and \( y = g(x) \) intersect are the solutions of the equation \( f(x) = g(x) \); find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where \( f(x) \) and/or \( g(x) \) are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.

Answer Key: C

A manufacturer compares its income, \( f(x) \), to its expenses, \( g(x) \), for \( x \) number of units sold.

What does the solution to \( f(x) = g(x) \) represent for the manufacturer?

A. the number of units sold when the manufacturer had an overall loss for the year

This answer is not correct. The student may have thought the point of intersection of the two functions is where the manufacturer had a loss.

B. the number of units sold when the manufacturer had an overall profit for the year

This answer is not correct. The student may have thought the point of intersection of the functions is where the manufacturer has a profit.

C. the number of units sold when the manufacturer’s income equaled the manufacturer’s expenses

This answer is correct. The student correctly identified the meaning of the two functions being equal.

D. the number of units sold when the manufacturer’s income and expenses were both positive values

This answer is not correct. The student may have misinterpreted the situation.
Question 11

**Reporting Category:** Algebraic Concepts & Procedures

**Common Core Standard:** A-REI.12: Graph the solutions to a linear inequality in two variables as a half-plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.

**Answer Key:** A

Which graph represents the solution set of the inequality $y \leq x - 4$?

A. 

This answer is correct. The correct boundary line is $y = x - 4$. It is a solid line, and part of the graph beneath the line is shaded because the inequality is "less than or equal to." Using test-point $(4, -2)$, the inequality is, $-2 < 4 - 4$ which is $-2 < 0$. This is a true statement.
B. This answer is not correct. The correct boundary line is a solid line at \( y = x - 4 \). But the top portion of the graph should not be shaded because the inequality is “less than or equal to.” Using test-point \((0, 0)\), the inequality is \( 0 < 0 - 4 \), which is \(0 < -4\). This is a false statement.

C. This answer is not correct. The boundary line should be solid because the inequality is “less than or equal to.”
This answer is not correct. The boundary line should be solid because the inequality is “less than or equal to.” The portion of the graph below the line should be shaded instead of the top portion because the inequality is “less than or equal to.”
**Question 12**

**Reporting Category:** Algebraic Concepts & Procedures

**Common Core Standard:** F-IF.2: Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.

The function for the profit, $p$, from selling glasses of lemonade, $L$, is shown.

$$p = 2L - 26$$

A. Drag numbers into the boxes to complete the table. Click the positive and negative signs to complete the number.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td>+</td>
</tr>
<tr>
<td>15</td>
<td>+</td>
</tr>
<tr>
<td>20</td>
<td>+</td>
</tr>
</tbody>
</table>

B. Drag numbers into the box to show the minimum number of glasses that need to be sold to make a profit.

**Scoring Rubric:**

2 points
For this item, the response correctly
- places the right values in the input-output table
  AND
- places the number of glasses in the box.

1 point
For this item, the response correctly
- answers either part A or part B.
**Sample Correct Answer:**

The function for the profit, $p$, from selling glasses of lemonade, $L$, is shown.

\[ p = 2L - 26 \]

A. Drag numbers into the boxes to complete the table. Click the positive and negative signs to complete the number.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>

B. Drag numbers into the box to show the minimum number of glasses that need to be sold to make a profit. 14 glasses

**Explanation of Correct Answer:**

In part A, the numbers in the output column must show the value of $p$ when $L$ is equal to the value in the input column. For example, when $L = 5$, the value of $p$ is given by:

\[ p = 2(5) - 26 \]
\[ p = 10 - 26 \]
\[ p = -16 \]

In part B, the minimum value needed to make a profit is equal to the smallest value of $L$ that results in a positive value of $p$. The table shows that values less than 10 are negative, and values greater than 15 are positive. So the number must be between 10 and 15. When $L$ is equal to 13, $p = 2 \cdot 13 - 26 = 0$. So the next-largest possible value, $L = 14$, is the smallest value that results in a positive $p$. 
Question 13

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: F-IF.6: Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

Movie theater ticket prices from 1990 to 2010 are shown in the graph.

What is the approximate rate of change from the price of movie tickets in 1990 to the price of movie tickets in 2010, in dollars per year?
Scoring Rubric:

1 point
For this item, the response correctly
- identifies a correct rate in decimal form.

Sample Correct Answer:

Movie theater ticket prices from 1990 to 2010 are shown in the graph.
What is the approximate rate of change from the price of movie tickets in 1990 to the price of movie tickets in 2010, in dollars per year?

0.18

Explanation of Correct Answer:

Use the Graphing Calculator tool. Select Regression. Enter the Years (x-values) of the points in the x column: 1990, 1995, 2000, 2005, 2010. Enter the Price (y-values) in the Y1 column: 4.2, 4.4, 5.4, 6.4, 7.8. Select Linear, because the points generally follow a linear trend. In the equation displayed, the slope represents the rate of change in decimal form. Thus, the approximate rate of change is 0.18.
Question 14

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: F-IF.9: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.

Two functions are shown.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$f(x)$</th>
<th>$g(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

$g(x) = \frac{1}{2}x + 3$

A. Use the Add Arrow tool to graph $f(x)$ and $g(x)$.

B. Drag the function with the greater rate of change into the box.

Scoring Rubric:

1 point
For this item, the response correctly
• draws both $f(x)$ and $g(x)$, and places $g(x)$ in the box.
Two functions are shown.

<table>
<thead>
<tr>
<th></th>
<th>f(x)</th>
<th>g(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

\[ g(x) = \frac{1}{2} x + 3 \]

A. Use the Add Arrow tool to graph \( f(x) \) and \( g(x) \).

B. Drag the function with the greater rate of change into the box.

**Explanation of Correct Answer:**

The function \( f(x) \) is the bottom line. Its \( y \)-intercept is at \((0, 0)\), based on values in the table. From plotting points in the table and connecting the line, it is apparent that the rate of change of \( f(x) \) is \( \frac{1}{3} \). The top line is \( g(x) \), which is already given as an equation in slope-intercept form. Its \( y \)-intercept is at \((0, 3)\), and its slope is \( \frac{1}{2} \). Plotting both \( f(x) \) and \( g(x) \) is correct for part A.

A linear function’s rate of change is the same as its slope, so \( g(x) \) is the function with the greater rate of change in part B.
Question 15

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** N-Q.2: Define appropriate quantities for the purpose of descriptive modeling.

**Answer Key:** B

The manager of a coffee shop suspects that as the outside temperature decreases in the evening, the number of hot beverages she sells will increase. The manager creates a model to see whether this is true.

What are the most appropriate variables for this model?

A. independent variable: number of hot beverages sold; dependent variable: hourly outside temperature

   *This answer is not correct. The student may not have understood that the hourly outside temperature does not depend on the number of hot beverages sold.*

B. independent variable: hourly outside temperature; dependent variable: number of hot beverages sold

   *This answer is correct. The student understands that the manager is interested in how the sales of hot beverages change based on temperature throughout the evening. Therefore, the hourly temperature and number of hot beverages sold are appropriate variables for this model.*

C. independent variable: number of hot beverages sold; dependent variable: average evening outside temperature

   *This answer is not correct. The student may not have understood that the average evening outside temperature does not depend on the number of hot beverages sold.*

D. independent variable: average evening outside temperature; dependent variable: number of hot beverages sold

   *This answer is not correct. The student may not have understood that "throughout the evening" indicates tracking temperature in units smaller than one evening.*
Question 16

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** A-CED.1: Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*

The height of a triangle is 4 feet less than the length of its base, $b$. The area of the triangle is 30 square feet.

Use the Connect Line tool to draw this triangle.

**Scoring Rubric:**

1 point
For this item, the response correctly
- includes a triangle with the proper base and height.
Sample Correct Answer:

The height of a triangle is 4 feet less than the length of its base, $b$. The area of the triangle is 30 square feet.

Use the Connect Line tool to draw this triangle.

Explanation of Correct Answer:

First, to write an equation to describe the situation, note that the formula for the area of a triangle $A$ is $A = \frac{1}{2} bh$. Since the height is 4 feet less than the length of the base, the height can be represented by $b - 4$. Then, substituting this expression for $h$ and the given area for $A$ in the formula gives the equation $30 = \frac{1}{2} b(b - 4)$. The steps to solve this equation for $b$ are shown below.

\[
30 = \frac{1}{2} b(b - 4) \\
60 = b(b - 4) \\
60 = b^2 - 4b \\
0 = b^2 - 4b - 60 \\
0 = (b - 10)(b + 6)
\]

Thus, the solutions for $b$ are 10 and $-6$. Since the length of the base cannot be negative, it must be 10 feet. Then, because the height of the triangle is given by $b - 4$, the height of the triangle is 6 feet. A correct response is obtained by drawing any triangle whose base is 10 feet and height is 6 feet.
Question 17

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** A-CED.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

A linear equation is shown.

\[3x + 2y = 6\]

Use the Add Arrow tool to graph this equation.

**Scoring Rubric:**

1 point
For this item, the response correctly
- draws a line with a slope of \(-\frac{3}{2}\) and a \(y\)-intercept of 3.
Sample Correct Answer:

A linear equation is shown.

$3x + 2y = 6$

Use the Add Arrow tool to graph this equation.

Explanation of Correct Answer:

The linear equation $3x + 2y = 6$ can be rewritten in slope-intercept form as $y = -\frac{3}{2}x + 3$. This form indicates that the line has a slope of $-\frac{3}{2}$ and a $y$-intercept at $(0, 3)$. 
Question 18

Reporting Category: Modeling & Problem Solving

Common Core Standard: A-SSE.1a: Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients.

Beth is running around a park on a trail that is 7 miles long. The number of miles Beth has run, \( d \), after \( t \) minutes is modeled by the equation shown.

\[ d = \frac{1}{15} t + 1 \]

Kyle is running around the same trail and starts at the same time as Beth. His speed is \( \frac{3}{4} \) as fast as Beth’s speed, and he starts a mile behind her.

Use the Connect Line tool to graph the equation that models Kyle’s run at this speed.

Scoring Rubric:

1 point
For this item, the response correctly
- graphs the equation.
Sample Correct Answer:

Beth is running around a park on a trail that is 7 miles long. The number of miles Beth has run, \(d\), after \(t\) minutes is modeled by the equation shown.

\[ d = \frac{1}{15}t + 1 \]

Kyle is running around the same trail and starts at the same time as Beth. His speed is \(\frac{3}{4}\) as fast as Beth’s speed, and he starts a mile behind her.

Use the Connect Line tool to graph the equation that models Kyle’s run at this speed.

Explanation of Correct Answer:

First, note that the slope of Beth’s equation indicates that she runs at a pace of \(\frac{1}{15}\) of a mile per minute. Since Kyle runs \(\frac{3}{4}\) as fast, he runs at a pace of \(\frac{1}{15} \cdot \frac{3}{4} = \frac{1}{20}\) of a mile per minute, and the slope of his equation should be \(\frac{1}{20}\).

Also, note that the \(y\)-intercept of Beth’s equation is 1, meaning that she starts 1 mile into the trail. Since Kyle starts a mile behind her, he starts at the beginning of the trail, and the \(y\)-intercept of his equation is 0. Thus, the equation that models Kyle’s run is

\[ d = \frac{1}{20}t. \]

To graph this equation, use the \(y\)-intercept and slope. Two points on the line are (0, 0) and (20, 1). Since the trail is 7 miles long, the line segment ends at (140, 7). The graph of the equation for Kyle’s run is determined by drawing a line segment connecting the points (0, 0) and (140, 7).
Question 19

Reporting Category: Modeling & Problem Solving

Common Core Standard: F-IF.4: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

Answer Key: B

Which graph changes from increasing to decreasing after \( y = 4 \)?

A.  

This answer is not correct. This graph changes from decreasing to increasing where \( y = 4 \), which is the opposite of the change we are looking for. The graph should have a maximum at that point, not a minimum.

B.  

This answer is correct. The graph has a maximum value at \( y = 4 \). This means that it
changes from increasing to decreasing at that point.

C.

This answer is not correct. The graph intersects y = 4, but it changes from decreasing to increasing, which is the opposite of the change we are looking for.

D.

This answer is not correct. This graph changes from increasing to decreasing at x = 4, not at y = 4.
Question 20

Reporting Category: Modeling & Problem Solving

Common Core Standard: F-IF.5: Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function $h(n)$ gives the number of person-hours it takes to assemble $n$ engines in a factory, then the positive integers would be an appropriate domain for the function.

Answer Key: A

A student creates a function to represent the cost of pencils available for purchase at the school store. The store charges 5 cents a pencil for up to 20 pencils.

What is the domain of this function?

A. all integers from 0 to 20

   *This answer is correct.* The student recognized the domain of the function.

B. all real numbers from 0 to 20

   *This answer is not correct.* The student may have thought that the domain was all real numbers but did not realize that you cannot buy part of a pencil.

C. all integer multiples of 5 from 5 to 100

   *This answer is not correct.* The student may have confused domain and range.

D. all real number multiples of 5 from 5 to 100

   *This answer is not correct.* The student may have confused the domain and range and thought the values were real numbers instead of integers.
**Question 21**

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** F-IF.8a: Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. 

a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

**Answer Key:** B

Steve drops a rock from a bridge that is 30 meters above the river. The height of the rock in meters, \( h \), after \( t \) seconds is modeled by the function shown.

\[ h(t) = -t^2 - 2t + 30 \]

Use the graphing calculator to approximate the number of seconds it will take for the rock to hit the water. Round your answer to the nearest whole number.

A. 0

*This answer is not correct. The student may have found the time when the rock was first released.*

B. 5

*This answer is correct.* Use the Graphing Calculator tool. Select Graphing. If not already highlighted in blue, select Expressions (Y=). Enter the equation as \( Y_1 = -x^2 - 2x + 30 \). Select Graph. Click Zoom Out twice. Both sides of the parabola are now visible. The right side of the parabola represents the section where the rock is dropping. The height when it hits the water is 0. \( h(t) = 0 \) is the x-axis. The parabola crosses the x-axis at about 4.5. It takes approximately 5 seconds for the rock to hit the water.

C. 10

*This answer is not correct. The student may have incorrectly factored the quadratic and found the zero of one of the factors.*

D. 30

*This answer is not correct. The student may have selected the starting height of the rock.*
Question 22

Reporting Category: Modeling & Problem Solving

Common Core Standard: F-BF.1a: Write a function that describes a relationship between two quantities. a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

An artist uses tiles to create a design. The design is created in stages and the total number of tiles the artist uses in each stage follows a pattern, as shown in the table.

<table>
<thead>
<tr>
<th>Stage Number</th>
<th>Total Number of Tiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
</tr>
</tbody>
</table>

Create an equation that models the number of tiles in a given stage.

Scoring Rubric:

1 point
For this item, the response correctly
- identifies an equivalent equation.
Sample Correct Answer:

An artist uses tiles to create a design. The design is created in stages and the total number of tiles the artist uses in each stage follows a pattern, as shown in the table.

**Artist’s Design**

<table>
<thead>
<tr>
<th>Stage Number</th>
<th>Total Number of Tiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
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<tr>
<td>4</td>
<td>7</td>
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<tr>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
</tr>
</tbody>
</table>

Create an equation that models the number of tiles in a given stage.

$$y = 2x - 1$$

Explanation of Correct Answer:

Since the difference between consecutive numbers of tiles is constant, the given information should be modeled by a linear equation.

To determine the slope of the equation, find the slope between any two points in the table. For example, find the slope between (1, 1) and (2, 3) as shown.

$$m = \frac{3 - 1}{2 - 1} = 2$$
To determine the $y$-intercept of the equation, use the value of $m$ and any point in the table in the equation $y = mx + b$ and solve. The steps to solve for $b$ using the point $(3, 5)$ from the table are shown.

\begin{align*}
y &= mx + b \\
5 &= (2)(3) + b \\
5 &= 6 + b \\
-1 &= b
\end{align*}

Thus, the equation that models the number of tiles is $y = 2x - 1$. 
Question 23

Reporting Category: Modeling & Problem Solving

Common Core Standard: F-LE.5: Interpret the parameters in a linear or exponential function in terms of a context.

The students in a science class constructed bridges made from toothpicks and glue. Each bridge was made following these rules:

- Each bridge used the same number of toothpicks.
- The width of each bridge was the same.
- The length of each bridge could vary.

Students recorded the maximum number of pennies each bridge could hold in a cup hanging from the center of the bridge before breaking. They called this number the breaking weight.

The function \( f(x) = -6x + 136 \) represents the breaking weight of the pennies, \( f(x) \), in terms of bridge length, \( x \).

What is the change in the breaking weight of the pennies, for each increase in one unit of the length of the bridge?

<table>
<thead>
<tr>
<th>x</th>
<th>f(x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-6</td>
</tr>
<tr>
<td>1</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>-4</td>
</tr>
<tr>
<td>3</td>
<td>-3</td>
</tr>
<tr>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>5</td>
<td>-1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
</tbody>
</table>

Scoring Rubric:

1 point
For this item, the response correctly
- identifies a value equivalent to 6 or -6.
Sample Correct Answer:

The students in a science class constructed bridges made from toothpicks and glue. Each bridge was made following these rules:

- Each bridge used the same number of toothpicks.
- The width of each bridge was the same.
- The length of each bridge could vary.

Students recorded the maximum number of pennies each bridge could hold in a cup hanging from the center of the bridge before breaking. They called this number the breaking weight.

The function \( f(x) = -6x + 136 \) represents the breaking weight of the pennies, \( f(x) \), in terms of bridge length, \( x \).

What is the change in the breaking weight of the pennies, for each increase in one unit of the length of the bridge?

\[ \boxed{-6} \]

Explanation of Correct Answer:

First, note that the length of the bridge is represented by the variable \( x \). The change in the value of \( y \) for each increase in one unit of \( x \) is given by the slope in a linear equation. Thus, since the breaking weight \( f(x) \) is given by the function \( f(x) = -6x + 136 \), the change in the breaking weight for each increase of one unit of the length of the bridge is -6.
Question 24

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** S-ID.6a: Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.

Scott records the number of people waiting at a bus stop throughout the afternoon and evening, as shown in the scatter plot.

Click a number or numbers to show the $y$-intercept for the line of best fit.

To help solve the problem, you can use the Add Arrow tool to draw the line of best fit.

**Scoring Rubric:**

1 point
For this item, the response correctly
- identifies a $y$-intercept of 2, 3, 4, or 5.
Sample Correct Answer:

Scott records the number of people waiting at a bus stop throughout the afternoon and evening, as shown in the scatter plot.

Click a number or numbers to show the y-intercept for the line of best fit.

To help solve the problem, you can use the Add Arrow tool to draw the line of best fit.

Explanation of Correct Answer:

To get a better idea of the answer, draw an approximate line of best fit on the provided scatter plot. Note that this line does not need to be included to get full credit for this response. Since the line drawn intersects the y-axis at $y = 4$, the y-intercept is 4. Any value from 2 through 5 inclusive would be acceptable for the y-intercept.
Question 25

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** S-ID.7: Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

**Answer Key:** A

The annual average temperature of a location depends in part on its distance from the equator. The latitude at the equator is 0. Scientists collected data from a number of locations. The line of best fit for the data is $y = 90 - x$, where $x$ is measured in degrees latitude and $y$ is measured in degrees Fahrenheit.

What is the meaning of the constant term in this equation?

A. It is the average temperature at the equator.

*This answer is correct. The constant term is the value of $y$ when $x = 0$. Thus, $y = 90$ when the latitude is 0, that is, at the equator.*

B. It is the rate of change in temperature at the equator.

*This answer is not correct. The student may have thought the constant term represented the rate of change.*

C. It is the number of different locations where data were collected.

*This answer is not correct. The student may have been confused by the equation parameters.*

D. It is the rate of decrease of 1 degree in temperature for each degree in distance from the equator.

*This answer is not correct. The student may have confused the meaning of slope and $y$-intercept.*
Question 26

**Reporting Category:** Modeling & Problem Solving

**Common Core Standard:** F-IF.8a: Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of the context.

A quadratic function is shown.

\[ f(x) = -x^2 + 7x - 12 \]

One factor of this function is \( (x - 4) \).

What is the other factor of the quadratic function?

---

**Scoring Rubric:**

1 point
For this item, the response correctly
• identifies the other factor.
Sample Correct Answer:

A quadratic function is shown.

\[ f(x) = -x^2 + 7x - 12 \]

One factor of this function is \((x - 4)\).

What is the other factor of the quadratic function?

\[
\left( -x + 3 \right)
\]

Explanation of Correct Answer:

The quadratic function can be factored as shown.

\[
\begin{align*}
  f(x) &= -x^2 + 7x - 12 \\
  &= -x^2 + 4x + 3x - 12 \\
  &= -x(x - 4) + 3(x - 4) \\
  &= (-x + 3)(x - 4)
\end{align*}
\]

Since the factor \((x - 4)\) is given, the other factor is \((-x + 3)\).

Sequence of Keypad Clicks to Enter the Answer:

\((, -, x, +, 3)\)
Question 27

Reporting Category: Algebraic Concepts & Procedures

Common Core Standard: A-SSE.3a: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. Factor a quadratic expression to reveal the zeros of the function it defines.

A quadratic equation is shown.

\[ x^2 + 2x - 15 = 0 \]

Factor the quadratic equation to show the zeros.

Scoring Rubric:

1 point
For this item, the response correctly
• identifies the equation.
Sample Correct Answer:

A quadratic equation is shown.

\[ x^2 + 2x - 15 = 0 \]

Factor the quadratic equation to show the zeros.

\[ (x - 3)(x + 5) = 0 \]

Explanation of Correct Answer:

The quadratic equation can be factored as shown.

\[ x^2 + 2x - 15 = 0 \]
\[ x^2 + 5x - 3x - 15 = 0 \]
\[ x(x + 5) - 3(x + 5) = 0 \]
\[ (x - 3)(x + 5) = 0 \]

Sequence of Keypad Clicks to Enter the Answer:

\( ( ), x, - , 3, \rightarrow(), x, + , 5, \rightarrow, = , 0 \)
Question 28

**Reporting Category:** Modeling with Problem Solving

**Common Core Standard:** F-BF.1a: Write a function that describes a relationship between two quantities. Determine an explicit expression, a recursive process, or steps for calculation from a context.

The table shows some values of a linear relationship between two quantities.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$f(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>?</td>
</tr>
<tr>
<td>?</td>
<td>42</td>
</tr>
<tr>
<td>14</td>
<td>60</td>
</tr>
</tbody>
</table>

Create a linear function $f(x)$ that represents this relationship in terms of $x$.

**Scoring Rubric:**

1 point
For this item, the response correctly
- identifies the function.
Sample Correct Answer:

The table shows some values of a linear relationship between two quantities.

<table>
<thead>
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</tr>
<tr>
<td>14</td>
<td>60</td>
</tr>
</tbody>
</table>

Create a linear function \( f(x) \) that represents this relationship in terms of \( x \).

\[
f(x) = 6x - 24
\]

**Explanation of Correct Answer:**

Since the function \( f(x) \) is linear, it will have the form \( (x) = mx + b \), where \( m \) is the slope of the line and \( b \) is the \( y \)-intercept of the line.

To determine the slope, find the slope between any two points in the table. For example, find the slope between (5, 6) and (14, 60) as shown.

\[
m = \frac{60 - 6}{14 - 5} = 6
\]

To determine the \( y \)-intercept, substitute the value of \( m \) and one of the points in the table in the function \( f(x) = mx + b \) and solve. The steps to solve for \( b \) using the point (5, 6) from the table are shown.

\[
y = mx + b
\]

\[
6 = (5)(6) + b
\]

\[
6 = 30 + b
\]

\[
-24 = b
\]
Thus, the linear function that models the number of tiles is $f(x) = 6x - 24$.

**Sequence of Keypad Clicks to Enter the Answer:**

$f(x), =, 6, x, -, 2, 4$
Question 29

Reporting Category: Modeling & Problem Solving

Common Core Standard: F-IF.5: Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function \( h(n) \) gives the number of person-hours it takes to assemble \( n \) engines in a factory, then the positive integers would be an appropriate domain for the function.

Answer Key: C

The function \( h(n) \) describes the total amount of money a movie theater receives for \( n \) tickets sold.

Which domain is appropriate for this function?

A. all integers

   *This answer is not correct. The student may have not understood that integers include negative numbers or that the number of tickets sold cannot be negative.*

B. all real numbers

   *This answer is not correct. The student may have incorrectly stated the domain of a linear function.*

C. all positive integers and zero

   *This answer is correct. The number of tickets sold must be a positive whole number.*

D. all positive real numbers and zero

   *This answer is not correct. The student may not have realized that the positive real numbers include fractions and decimals which are not possible since only whole tickets can be sold to a movie theater.*