Item Position	Rationale	
1	Option D is correct	To determine the equivalent expression, the student could have rewritten $7\sqrt{45}$ as $7\sqrt{9 \cdot 5}$ and then calculated the square root (a value that when multiplied by itself is equal to the number under the $\sqrt{\ }$) of 9, to get $(7 \cdot 3)\sqrt{5}$, or $21\sqrt{5}$. This is an efficient way to solve the problem; however, other met hods could be used to solve the problem correctly.
	Option A is incorrect	The student likely reversed the placement of the values 3 and 5 after calculating the square root and then added 7 and 5, resulting in $(7 + 5)\sqrt{3}$, or $12\sqrt{3}$. The student needs to focus on understanding how to simplify square roots.
	Option B is incorrect	The student likely reversed the placement of the values 3 and 5 after calculating the square root, resulting in $(7 \cdot 5)\sqrt{3}$, or $35\sqrt{3}$. The student needs to focus on understanding how to simplify square roots.
	Option C is incorrect	The student likely added 7 and 3, resulting in $(7 + 3)\sqrt{5}$, or $10\sqrt{5}$. The student needs to focus on understanding how to simplify square roots.

Item Position	Rationale	
2	Option A is correct	To determine the function that best represents the graph, the student could have identified the zeros (x-values where y is equal to zero) of the function as u and v and used the solutions to construct the equation of a quadratic function using $h(x) = a(x - u)(x - v)$, where a, u, and v are real numbers. The student could have identified the zeros of the function as $x = -5$ and $x = -3$ since the graph shows that these values produce $y = 0$. Letting $u = -5$ and $v = -3$, the student could have substituted those values in the equation $h(x) = a(x - u)(x - v)$, resulting in $h(x) = a[x - (-5)][x - (-3)]$, or $h(x) = a(x + 5)(x + 3)$. The student could have then multiplied the expressions $(x + 5)$ and $(x + 3)$, resulting in $h(x) = a(x^2 + 3x + 5x + 15)$, or $h(x) = a(x^2 + 8x + 15)$. Next, the student could have solved for a by substituting the coordinates of the vertex (highest or lowest point of the curve), $(-4, 1)$, into the function $h(x) = a(x^2 + 8x + 15)$, resulting in $1 = a[(-4)^2 + 8(-4) + 15] \rightarrow 1 = a(16 - 32 + 15) \rightarrow 1 = -a \rightarrow -1 = a$. The student could have then substituted -1 for a in the function $h(x) = a(x^2 + 8x + 15)$, resulting in $h(x) = -(x^2 + 8x + 15)$, or $h(x) = -x^2 - 8x - 15$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely made a sign error when substituting $u = -5$ and $v = -3$ into the equation $h(x) = a(x - u)(x - v)$, resulting in $h(x) = a(x - 5)(x - 3)$. The student needs to focus on understanding how to identify the zeros of a quadratic function and write the equation of the function using those values.
	Option C is incorrect	The student likely did not find the value of a when writing the equation of the quadratic function, resulting in $h(x) = (x + 5)(x + 3)$, or

		$h(x) = x^2 + 8x + 15$. The student needs to focus on understanding how to identify the zeros of a quadratic function and write the equation of the function using those values.
	Option D is incorrect	The student likely made a sign error when substituting $u = -5$ and $v = -3$ into the equation $h(x) = a(x - u)(x - v)$, resulting in $h(x) = a(x - 5)(x - 3)$. The student then likely did not find the value of a when writing the equation of the quadratic function, resulting in $h(x) = (x - 5)(x - 3)$, or $h(x) = x^2 - 8x + 15$. The student needs to focus on understanding how to identify the zeros of a quadratic function and write the equation of the function using those values.

Item Position	Rationale	
3	−3, 18	To determine constant of variation when y is a function of x in a relationship where y varies directly with x, the student could have recognized that the relationship can be represented by the equation $y = kx$, where k is the constant of variation. To determine the value of k, the student could have substituted $x = 4$ and $y = -12$ into the equation and solved for k, resulting in $-12 = 4k$ or $-3 = k$. To determine the value of y when $x = -6$ from the same relationship, the student could have used the constant of variation to write the equation $y = -3x$. Next, the student could have substituted $x = -6$ into the equation and solved for y, resulting in $y = -3(-6)$ or $y = 18$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
4	Option A is correct	To determine which graph best represents a quadratic function that has no real zeros, the student could have analyzed the parabola (U-shaped graph) graphed on the grid. The student could have recognized that the graph of the function has no *x*-intercepts (points where the curve touches the *x*-axis [horizontal number line]). The student then should have concluded that the function has no real zeros since the graph of the function has no values of *x* that produce $y = 0$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely assumed that since the parabola has no visible *y*-intercept, the function has no real zeros. The student needs to focus on understanding how to identify the key features of a quadratic function when given a graph of the function.
	Option C is incorrect	The student likely assumed that since the parabola does not pass through the origin, (0, 0), the function has no real zeros. The student needs to focus on understanding how to identify the key features of a quadratic function when given a graph of the function.
	Option D is incorrect	The student likely recognized that the parabola touches the *x*-axis at zero but did not consider $x = 0$ a zero of the function since the curve does not cross the *x*-axis. The student needs to focus on understanding how to identify the key features of a quadratic function when given a graph of the function.

Item Position	Rationale	
5	Option C is correct	To determine the statement that best interprets one value in the function, the student should have recognized that $A(t)$ is an exponential function of the form $A(t) = ab^t$, where a represents the initial value (starting value), b represents the common factor (constant rate by which successive values increase or decrease), and t is the variable (symbol used to represent an unknown number). In this situation, the variable t represents the number of years after the investor deposited the initial amount of money. In $A(t) = 1{,}550(1.02)^t$, the student should have recognized that the initial deposit in the investment account was $1,550 since $a = 1{,}550$.
	Option A is incorrect	The student likely interpreted the initial value as the value of y when $x = 1$ instead of when $x = 0$. The student needs to focus on interpreting the meaning of the values of a and b in an exponential function of the form $A(t) = ab^t$.
	Option B is incorrect	The student correctly interpreted the function as an increasing function since $b > 1$ but interpreted $b = 1.02$ as the growth rate instead of subtracting 1 from the growth factor. The student needs to focus on interpreting the meaning of the values of a and b of an exponential function of the form $A(t) = ab^t$.
	Option D is incorrect	The student correctly subtracted 1 from the b-value to determine the rate, resulting in $1 - 1.02 = 0.02$ or 2%, but interpreted the function as a decreasing function instead of an increasing function. The student needs to focus on interpreting the meaning of the values of a and b of an exponential function of the form $A(t) = ab^t$.

Item Position	Rationale	
6	Option B is correct	To determine the equivalent expression, the student could have first applied the power of a power property $[(a^m)^n = a^{mn}]$ to $(6x^2y)^2$, resulting in $\frac{1}{3}\left(6^2x^{2(2)}y^{1(2)}\right)(2x^3y^4)$, or $\frac{1}{3}(36x^4y^2)(2x^3y^4)$. Next, the student could have applied the product of powers property ($a^ma^n = a^{m+n}$), resulting in $\frac{1}{3}(36)(2)x^{4+3}y^{2+4}$, or $24x^7y^6$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely applied the power of a power and product of powers properties only to the variables and then found the product of the coefficients, resulting in $4x^7y^6$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.
	Option C is incorrect	The student likely found the product of the coefficients but multiplied the exponents for each variable instead of applying the power of a power and product of powers properties, resulting in $4 \cdot x^{2(2)(3)} \cdot y^{1(2)(4)}$ or $4x^{12}y^8$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.
	Option D is incorrect	The student likely applied the power of a power property to $(6x^2y)^2$ but then multiplied the exponents for each variable instead of applying the product of powers property, resulting in $24x^{4(3)}y^{2(4)}$ or $24x^{12}y^8$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.

Item Position	Rationale	
7	Option C is correct	To determine the rate of change (constant rate of increase or decrease), the student could have rewritten the equation in slope-intercept form ($y = mx + b$, where m represents the slope [steepness of a straight line when graphed on a coordinate grid] of the line and b represents the value of the y-intercept [value where a graph crosses the y-axis]). First, the student could have subtracted $5x$ from both sides of the equation, resulting in $-8y = -5x + 40$. Next, the student could have divided both sides of the equation by −8, resulting in $y = \frac{5}{8}x - 5$. Last, the student could have interpreted the slope of the line, $m = \frac{5}{8}$, as the rate of change of y with respect to x for the equation. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely interchanged the variables b – $8x = 40$. Then the student likely tried to write the equation in slope-intercept form by solving the equation for y but moved the $-8x$ term to the right side without using the inverse operation, resulting in $5y = -8x + 40$, or $y = -\frac{8}{5}x + 8$. Then the student likely interpreted the slope of the line, $m = -\frac{8}{5}$, as the rate of change. The student needs to focus on understanding how to convert linear equations from standard form ($ax + by = c$ where a, b, and c are integers) or other forms into slope-intercept form.
	Option B is incorrect	The student likely added $5x$ to the right side of the equation instead of subtracting $5x$, resulting in $-8y = 5x + 40$ or $y = -\frac{5}{8}x + 5$. Then the student likely interpreted the slope of the line, $m = -\frac{5}{8}$, as the rate of change. The student needs to focus on understanding how to

		convert linear equations from standard form or other forms into slope-intercept form.
	Option D is incorrect	The student likely interchanged the variables before writing the equation in slope-intercept form, resulting in 5*y* – 8*x* = 40. Then the student likely wrote the equation in slope-intercept form by solving the equation for *y*, resulting in $y = \frac{8}{5}x + 8$. Then the student likely interpreted the slope of the line, $m = \frac{8}{5}$, as the rate of change. The student needs to focus on understanding how to convert linear equations from standard form or other forms into slope-intercept form.

Item Position	Rationale	
8	−14, 61	To determine the equation that can be used to find the nth term of the sequence, a_n, the student could have recognized that the pattern in the sequence is arithmetic (sequence of numbers where the difference between every two consecutive terms is the same). The student then could have found the common difference between the first two consecutive terms, resulting in $d = 33 - 47 = -14$. Next, the student could have substituted $a_1 = 47$ and $d = -14$ into the formula for an arithmetic sequence ($a_n = a_1 + (n - 1)(d)$, where n represents the position of the nth term, a_1 represents the first term, and d represents the common difference), resulting in $a_n = 47 + (n - 1)(-14)$, $a_n = 47 - 14n + 14$, and $a_n = -14n + 61$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
9	Option D is correct	To determine the range (all possible *y*-values) of the function, the student could have graphed the quadratic function and analyzed the parabola (U-shaped graph). The student could have determined that the graph extends downward and outward indefinitely, and the vertex (highest or lowest point of the curve) is located at (30, 900). The student could have identified $y = 900$ as the maximum value of the function since the graph continues downward from the vertex. Since $y = 900$ is the maximum value of the function, the student could have concluded that the range of the function is all real numbers that are less than or equal to 900. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely identified the range of the function as the positive *x*-values where the graph is increasing. The student needs to focus on understanding how to represent the range of a quadratic function.
	Option B is incorrect	The student likely identified the range of the function as the positive *x*-values. The student needs to focus on understanding how to represent the range of a quadratic function.
	Option C is incorrect	The student likely interpreted the range of the function as greater than or equal to the maximum value of the function. The student needs to focus on understanding how to represent the range of a quadratic function.

Item Position	Rationale	
10	Option A is correct	To determine the type of linear association that exists between hours worked and overall grade average, the student should have determined the correlation coefficient (a value, represented by *r*, that measures the strength of a linear association) using the linear regression feature on a graphing calculator. The correlation coefficient that best models this set of data is $r \approx -0.9004$. Since the correlation coefficient is negative and close to –1, there is a strong negative linear association.
	Option B is incorrect	The student likely identified $-(1 + r)$ as the correlation coefficient, resulting in $-(1 - 0.9004) = -0.0996$. Since this value is negative and close to zero, the student likely interpreted the linear association as weak negative. The student needs to focus on understanding how to determine the correlation coefficient between two quantitative variables and how to interpret this quantity as a measure of the strength of the linear association.
	Option C is incorrect	The student likely identified $(1 + r)$ as the correlation coefficient, resulting in $(1 - 0.9004) = 0.0996$. Since this value is positive and close to zero, the student likely interpreted the linear association as weak positive. The student needs to focus on understanding how to determine the correlation coefficient between two quantitative variables and how to interpret this quantity as a measure of the strength of the linear association.
	Option D is incorrect	The student likely took the absolute value (how far a number is from zero) of the correlation coefficient, resulting in $r \approx 0.9004$. Since this value is close to 1, the student likely interpreted the linear association as strong positive. The student needs to focus on understanding how to determine the correlation coefficient between two quantitative variables and how to interpret this quantity as

		a measure of the strength of the linear association.

Item Position	Rationale	
11	Option C is correct	To determine which statement about the graph of $y = 16(0.5)^x$ is not true, the student could have graphed the function on a coordinate grid. First, the student could have recognized that the graph is decreasing for all values of x since the values of y decrease as the values of x increase. Next, the student could have recognized that the graph intersects (crosses) the y-axis (vertical number line) at 16, so (0, 16) represents the y-intercept. Last, the student could have recognized that the graph extends infinitely to the left and the right and never crosses the x-axis (horizontal axis), so the graph of the function has a horizontal asymptote at $y = 0$ and has no x-intercepts (points where the curve touches the x-axis [horizontal number line]). Therefore, the statement "the x-intercept is (0.5, 0)" is not true. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely graphed the function but interpreted the y-intercept at (0, 16) as intersecting (crossing) the x-axis instead of the y-axis. The student needs to focus on understanding how to identify the key features of exponential functions of the form $y = ab^x$.
	Option B is incorrect	The student likely interpreted the a-value in the exponential function $y = ab^x$ as a growth factor since $a > 1$ instead of interpreting it as the initial value (starting value). The student needs to focus on understanding how to identify the key features of exponential functions of the form $y = ab^x$.
	Option D is incorrect	The student likely interpreted the horizontal asymptote, $y = 0$, as the y-intercept. The student needs to focus on understanding how to identify the key features of exponential functions of the form $y = ab^x$.

Item Position	Rationale	
12	Solid line going through (0, −2) and (2, −1); shading the area that includes the point (0, 0)	To determine the solution set for the linear inequality $y \geq \frac{1}{2}x - 2$, the student should have recognized that the graph of the solution set would have a solid boundary line since the inequality symbol "≥" is given. To graph the boundary line, the student could have used a slope (steepness of a straight line when graphed on a coordinate grid) of $\frac{1}{2}$ and a *y*-intercept (value where a graph crosses the *y*-axis) of −2. The student could have determined the correct half plane to be shaded by substituting (0, 0) into the inequality to test for a true statement. Since $0 \geq \frac{1}{2}(0) - 2$ is a true statement, the ordered pair (0, 0) should be included in the solution set. Therefore, the student should have shaded the half plane that contains the point (0, 0). This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

<table>
<tr><th>Item Position</th><th colspan="2">Rationale</th></tr>
<tr><td rowspan="3">13</td><td>Option A is correct</td><td>To determine the cost of 1 cup of coffee, the student could have set up and solved a system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]). If x represents the cost of 1 cup of coffee and y represents the cost of 1 doughnut, the student could have set up two equations:

$x + 2y = 4.90$
(1 cup of coffee and 2 doughnuts for a total cost of $4.90) and
$2x + 3y = 8.60$
(2 cups of coffee and 3 doughnuts for a total cost of $8.60).

Next, the student could have solved the system of equations using the elimination method. The student could have multiplied the first equation by 2, resulting in $2x + 4y = 9.80$. Next, the student could have subtracted the second equation from this equation, resulting in $(2x + 4y) - (2x + 3y) = 9.80 - 8.60$, or $y = 1.20$. Last, the student could have substituted $y = 1.20$ back into the first equation and solved for x, resulting in $x + 2(1.20) = 4.90$, $x + 2.40 = 4.90$, and $x = 2.50$. Since x represents the cost of 1 cup of coffee, the student could have concluded that the cost of 1 cup of coffee is $2.50. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.</td></tr>
<tr><td>Option B is incorrect</td><td>The student likely set up and solved the system of equations correctly but found the cost of 1 doughnut, $1.20, instead of the cost of 1 cup of coffee. The student needs to focus on understanding what value each variable represents in terms of the situation when solving a system of equations.</td></tr>
<tr><td>Option C is incorrect</td><td>The student likely selected the total cost from the first customer, $4.90, since this customer purchased 1 cup of coffee. The student needs</td></tr>
</table>

		to focus on understanding how to write and solve a system of equations from a verbal description.
	Option D is incorrect	The student likely selected the difference between the total costs for the two customers, \$8.60 - \$4.90 = \$3.70, since the second customer purchased 1 additional cup of coffee and 1 additional doughnut. The student needs to focus on understanding how to write and solve a system of equations from a verbal description.

Item Position	Rationale	
14	Option C is correct	To determine the equation that is best represented by the graph, the student could have used the slope-intercept form of a linear equation ($y = mx + b$, where $m = \frac{y_2 - y_1}{x_2 - x_1}$ represents the slope of the line and b represents the value of the y-intercept). The student could have recognized that the line intersects (crosses) the y-axis (vertical axis) at (0, −5) and concluded that $b = -5$. Then the student could have recognized that the line intersects the x-axis (horizontal axis) at (−3, 0). Next, the student could have substituted the ordered pairs (0, −5) and (−3, 0) into the slope formula, resulting in $m = \frac{0-(-5)}{-3-0} = -\frac{5}{3}$. Last, the student could have substituted $m = -\frac{5}{3}$ and $b = -5$ into $y = mx + b$, obtaining $y = -\frac{5}{3}x - 5$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely identified the correct value of the y-intercept but divided the change in x by the change in y to find the slope of the line, resulting in $m = \frac{-3-0}{0-(-5)} = -\frac{3}{5}$. The student needs to focus on understanding how to write a linear function in slope-intercept form when given a graph.
	Option B is incorrect	The student likely used the value of the x-intercept (value where the graph crosses the x-axis) for b, resulting in $b = -3$, and divided the change in x by the change in y to find the slope of the line, resulting $m = \frac{-3-0}{0-(-5)} = -\frac{3}{5}$. The student needs to focus on understanding how to write a linear function in slope-intercept form when given a graph.
	Option D is incorrect	The student likely calculated the slope of the line correctly but used the value of the x-intercept for b, resulting in $b = -3$. The student needs to focus on understanding how to write a

		linear function in slope-intercept form when given a graph.

Item Position	Rationale	
15	Option B is correct	To determine the best estimate for the number of hours the two hikers have been hiking when they are the same distance from the start of the trail, the student could have recognized that the two lines on the coordinate grid intersect (cross). The student then could have estimated that the two lines intersect at (1.3, 4.5). Since x represents the time in hours, the student could have concluded that the two hikers have been hiking for 1.3 hours when they are the same distance from the start of the trail. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely used the time when the first hiker is 8 miles from the start of the trail, 2.8 hours. The student needs to focus on estimating the solution to a system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]) using the graphing method.
	Option C is incorrect	The student likely used the y-intercept value of the line for the second hiker, resulting in 2.5 hours. The student needs to focus on estimating the solution to a system of equations using the graphing method.
	Option D is incorrect	The student likely estimated the distance from the start of the trail instead of the number of hours, resulting in 4.5 hours. The student needs to focus on interpreting the point of intersection of two intersecting lines.

Item Position	Rationale	
16	Option A is correct	To determine which function is equivalent to $f(x) = 6x^2 - 23x + 21$, the student could have recognized the need to find the factors (numbers or expressions that can be multiplied to get another number or expression) of $6x^2 - 23x + 21$. The student could have first multiplied $6x^2$ by 21, resulting in $126x^2$. The student then could have identified the two terms that have a product of $126x^2$ and a sum of $-23x$, which are $-9x$ and $-14x$. Next, the student could have rewritten the function in expanded form using these two terms, resulting in $f(x) = 6x^2 - 9x - 14x + 21$. The student could have grouped the first two terms and last two terms and factored out the greatest (largest) common factor from each group of terms, resulting in $f(x) = (6x^2 - 9x) + (-14x + 21) = 3x(2x - 3) - 7(2x - 3)$. Last, the student could have factored out the binomial $(2x - 3)$, resulting in $f(x) = (3x - 7)(2x - 3)$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely determined the correct expanded form of the function, $f(x) = 6x^2 - 9x - 14x + 21$, but switched the constant terms when factoring out the common factor from each group, resulting in $f(x) = (3x - 3)(2x - 7)$. Then the student likely factored out a 3 from the factor $(3x - 3)$, resulting in $f(x) = 3(x - 1)(2x - 7)$. The student needs to focus on understanding how to factor a quadratic equation of the form $f(x) = ax^2 + bx + c$.
	Option C is incorrect	The student likely determined that two factors of $6x^2$ are $6x$ and x and that two factors of 21 are -7 and -3 but disregarded the value of the linear term (middle term, or the term with a degree of 1) of the quadratic function, resulting in $f(x) = (6x - 7)(x - 3)$. The student needs to focus on understanding how to factor a

		quadratic function of the form $f(x) = ax^2 + bx + c$.
	Option D is incorrect	The student likely determined that two factors of $6x^2$ are $6x$ and x and that two factors of 21 are –7 and –3 but disregarded the value of the linear term (middle term, or the term with degree of 1) of the quadratic function, resulting in $f(x) = (x - 7)(6x - 3)$. Then the student likely factored out a 3 from the factor $(6x - 3)$, resulting in $f(x) = 3(x - 7)(2x - 1)$. The student needs to focus on understanding how to factor a quadratic function of the form $f(x) = ax^2 + bx + c$.

Item Position	Rationale	
17	Option B is correct	To determine which statement is true about the domain (all possible *x*-values) of the part of the exponential function graphed on the grid, the student could have identified all the values of *x* for which the graph has a *y*-value. The student could have recognized that the graph contains a closed circle at (2, 1), meaning that the *x*-values of the function starts at and includes the value 2. The student then could have recognized that the graph extends upward and to the right until it reaches the point (5, 8), where it contains a closed circle, meaning that the *x*-values of the function end at and include the value 5. Therefore, the domain of the part of the function shown is the set of all real numbers greater than or equal to 2 and less than or equal to 5. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option D is correct	To determine which statement is true about the range (all possible *y*-values) of the part of the exponential function graphed on the grid, the student could have identified all the values of *y* for which the graph has an *x*-value. The student could have recognized that the graph contains a closed circle at (2, 1), meaning that the *y*-values of the function start at and include the value 1. The student then could have recognized that the graph extends upward and to the right until it reaches the point (5, 8), where it contains a closed circle, meaning that the *y*-values of the function end at and include the value 8. Therefore, the range of the part of the function shown is the set of all real numbers greater than or equal to 1 and less than or equal to 8. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely identified the set of values of the range as the domain. The student needs to focus on understanding how to represent the

		domain and range of an exponential function when given a part of the graph.
	Option C is incorrect	The student likely identified the domain of an unbounded exponential function. The student needs to focus on understanding how to represent the domain and range of an exponential function when given a part of the graph.
	Option E is incorrect	The student likely identified the set of values of the domain as the range. The student needs to focus on understanding how to represent the domain and range of an exponential function when given a part of the graph.
	Option F is incorrect	The student likely identified the set of values of the domain of an unbounded exponential function as the range. The student needs to focus on understanding how to represent the domain and range of an exponential function when given a part of the graph.

Item Position	Rationale	
18	Option B is correct	To determine the solutions to $g(x) = 0$, the student could have set the function equal to zero and solved the resulting equation, $3x^2 - 2x - 5 = 0$. To solve this equation, the student could have found the factors (numbers or expressions that can be multiplied to get another number or expression) of $3x^2 - 2x - 5$. The student could have first multiplied $3x^2$ by -5, resulting in $-15x^2$. The student then could have identified the two terms that have a product of $-15x^2$ and a sum of $-2x$, which are $-5x$ and $3x$. Then the student could have rewritten the expression in expanded form using these two terms, resulting in $3x^2 + 3x - 5x - 5$. The student could have grouped the first two terms and last two terms and factored out the greatest (largest) common factor from each group of terms, resulting in $(3x^2 + 3x) + (-5x - 5)$, or $3x(x + 1) - 5(x + 1)$. Next, the student could have factored out the binomial $(x + 1)$, resulting in $(3x - 5)(x + 1)$. Then the student could have set each factor equal to zero and solved each equation for x. To solve $3x - 5 = 0$, the student could have added 5 to both sides of the equation, resulting in $3x = 5$, and then divided both sides of the equation by 3, resulting in $x = \frac{5}{3}$. To solve $x + 1 = 0$, the student could have subtracted 1 from both sides of the equation, resulting in $x = -1$. Last, the student could have concluded that the solutions to $g(x) = 0$ are $x = -1$ and $x = \frac{5}{3}$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely switched the numerator (top number in a fraction) and denominator (bottom number in a fraction) when dividing 5 and 3, resulting in $x = \frac{3}{5}$. The student needs to focus on how to find the factors and solutions of a quadratic equation.

	Option C is incorrect	The student likely made a sign error when finding the factors, resulting in $(3x + 5)(x - 1) = 0$. The student then likely switched the numerator and denominator when dividing 5 and 3, resulting in $x = -\frac{3}{5}$. The student needs to focus on how to find the factors and solutions of a quadratic equation.
	Option D is incorrect	The student likely made a sign error when finding the factors, resulting in $(3x + 5)(x - 1) = 0$. The student needs to focus on how to find the factors and solutions of a quadratic equation.

Item Position	Rationale	
19	Option C is correct	To determine which function represents the relation shown in the table, the student should have recognized that an exponential function is of the form $g(x) = ab^x$, where *a* is the initial value (starting value), *b* is the common factor (constant rate by which successive values increase or decrease), and *x* is the variable (symbol used to represent an unknown number). From the information given in the table, the student could have determined the common factor, *b*, by dividing each value of $g(x)$ by the previous value of $g(x)$, resulting in $b = \frac{162}{108} = \frac{108}{72} = \frac{72}{48} = \frac{3}{2}$. Then the student could have determined the initial value, *a*, by dividing the value of $g(x)$ when $x = 1$ by the common factor, *b*, resulting in $a = \frac{48}{1.5} = 32$. The student then could have substituted $a = 32$ and $b = \frac{3}{2}$ into the exponential equation $g(x) = ab^x$ to obtain $g(x) = 32\left(\frac{3}{2}\right)^x$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely determined the common factor, *b*, by dividing each value of $g(x)$ by the subsequent value of $g(x)$, resulting in $b = \frac{48}{72} = \frac{2}{3}$. Next, the student likely determined the initial value, *a*, by multiplying the value of $g(x)$ when $x = 1$ by the common factor, *b*, resulting in $a = 48\left(\frac{2}{3}\right) = 32$. Then the student likely substituted $a = 32$ and $b = \frac{2}{3}$ into the exponential equation $g(x) = ab^x$ to obtain $g(x) = 32\left(\frac{2}{3}\right)^x$. The student needs to focus on understanding how to determine the common factor and the initial value of an exponential function from the given information.
	Option B is incorrect	The student likely determined the common factor, *b*, by dividing each value of $g(x)$ by the subsequent value of $g(x)$, resulting in $b = \frac{48}{72} = \frac{2}{3}$. Next, the student likely identified the

		initial value, *a*, as the value of $g(x)$ when $x = 1$ instead of when $x = 0$, resulting in $a = 48$. Then the student likely substituted $a = 48$ and $b = \frac{2}{3}$ into the exponential equation $g(x) = ab^x$ to obtain $g(x) = 48\left(\frac{2}{3}\right)^x$. The student needs to focus on understanding how to determine the common factor and the initial value of an exponential function from the given information.
	Option D is incorrect	The student correctly determined that the value of *b* is $\frac{3}{2}$ but likely identified the initial value, *a*, as the value of $g(x)$ when $x = 1$ instead of when $x = 0$, resulting in $a = 48$. Then the student likely substituted $a = 48$ and $b = \frac{3}{2}$ into the exponential equation $g(x) = ab^x$ to obtain $g(x) = 48\left(\frac{3}{2}\right)^x$. The student needs to focus on understanding how to determine the initial value of an exponential function from the given information.

Item Position	Rationale	
20	Option A is correct	To determine the situation that best represents association but not causation (in which an event is the result of the occurrence of another event), the student should have recognized that the number of spectators at a football game does not cause the number of wins for the home team to change.
	Option B is incorrect	The student likely did not realize that the two events are related and that the number of gallons of water put into an aquarium affects the weight of the aquarium. The student needs to focus on understanding causation in real-world problems.
	Option C is incorrect	The student likely did not realize that the two events are related and that the amount of time an athlete runs affects the distance the athlete runs. The student needs to focus on understanding causation in real-world problems.
	Option D is incorrect	The student likely did not realize that the two events are related and that the charge of a cell phone battery affects the number of minutes the phone can be used. The student needs to focus on understanding causation in real-world problems.

Item Position	Rationale	
21	Option B is correct	To determine the equation for g, the student could have first identified $f(x) = x^2$ as the quadratic parent function and represented the new function using the equation $g(x) = af(x - c) + d$, where a represents the vertical stretch, c represents the horizontal translation, and d represents the vertical translation. Then the student could have recognized that vertex of the graph of f is translated 3 units to the left and 2 units down to create the graph of g. Since c represents the horizontal translation, the student could have concluded that $c = -3$. Since d represents the vertical translation, the student could have concluded that $d = -2$. Next, the student could have recognized that the graph of f is stretched vertically by a factor of 2 to create the graph of g. Since a represents the vertical stretch, the student could have concluded that $a = 2$. Last, the student could have substituted $a = 2$, $c = -3$, and $d = -2$ into the equation $g(x) = af(x - c) + d$ to obtain $g(x) = 2f(x - (-3)) + (-2)$, or $g(x) = 2f(x + 3) - 2$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely did not recognize that the graph of f was vertically stretched by a factor of 2 to create the graph of g and selected the equation $g(x) = f(x + 3) - 2$. The student needs to focus on understanding how transformations of the graph of a function affect the equation of the function.
	Option C is incorrect	The student likely did not recognize that the graph of f was vertically stretched by a factor of 2 to create the graph of g and made sign errors when substituting $c = -3$ and $d = -2$ into the equation $g(x) = af(x - c) + d$. Therefore, the student selected the equation $g(x) = f(x - 3) + 2$. The student needs to focus on understanding how transformations of the

		graph of a function affect the equation of the function.
	Option D is incorrect	The student likely made sign errors when substituting $c = -3$ and $d = -2$ into the equation $g(x) = af(x - c) + d$ and selected the equation $g(x) = 2f(x - 3) + 2$. The student needs to focus on understanding how transformations of the graph of a function affect the equation of the function.

Item Position	Rationale	
22	A line going through (0, 2) and (3, 0)	To graph the line represented by the equation $2x + 3y = 6$, the student could have found the x- and y-intercepts of the line. The student could have substituted $x = 0$ into the equation and solved for y to determine the y-intercept (value where a graph crosses the y-axis) of the line, resulting in $2(0) + 3y = 6$, $3y = 6$, and $y = 2$. Since the value of the y-intercept is 2, the line passes through the point (0, 2). Next, the student could have substituted $y = 0$ into the equation and solved for x to determine the x-intercept (value where a graph crosses the x-axis) of the line, resulting in $2x + 3(0) = 6$, $2x = 6$, and $x = 3$. Since the value of the x-intercept is 3, the line passes through the point (3, 0). This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
23	Option B is correct	To determine the domain (all possible *x*-values) and range (all possible *y*-values) of the function, the student should have recognized that the situation represents a linear function with discrete values since the swimming pool can be rented only for 1 hour or 2 hours. The student should have recognized that the number of hours the pool is rented is represented by *x*, so the domain of the function is {1, 2} since the pool can be rented only for 1 hour or 2 hours. The student should have also recognized that the cost in dollars to rent the pool is represented by *y* and that $y = 110x$ could be used to model the situation since the swimming pool can be rented for $110 per hour. Substituting $x = 1$ and $x = 2$ into $y = 110x$, the student should have found that $y = 110$ and $y = 220$, respectively. The student should have then concluded that the range of the function is {110, 220}.
	Option A is incorrect	The student likely switched the domain and range values. The student needs to focus on understanding how to identify the domain and range of a linear function with discrete values.
	Option C is incorrect	The student likely found the domain and range for a linear function that is unbounded and continuous. The student needs to focus on understanding how to identify the domain and range of a linear function with discrete values.
	Option D is incorrect	The student likely recognized that the situation represents a linear function with discrete values but did not recognize that the set of discrete values is bounded. The student needs to focus on understanding how to identify the domain and range of a linear function with discrete values.

Item Position	Rationale	
24	Option A is correct	To determine value of *m* that makes the equation $\frac{2}{3}(m-9)=\frac{1}{3}(m-27)$ true, the student could have first distributed (multiplied) the numbers in front of the parentheses to each term inside the parentheses, resulting in $\frac{2}{3}m-6=\frac{1}{3}m-9$. Next, the student could have subtracted $\frac{1}{3}m$ from both sides of the equation, resulting in $\frac{1}{3}m-6=-9$. The student then could have added 6 to both sides of the equation, resulting in $\frac{1}{3}m=-3$. Last, the student could have multiplied both sides of the equation by 3, resulting in $m = -9$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely added instead of subtracting when moving $\frac{1}{3}m$ across the equal sign, resulting in $m - 6 = -9$. Then the student likely added 6 to both sides of the equation to obtain $m = -3$. The student needs to focus on understanding the arithmetic of solving equations.
	Option C is incorrect	The student likely divided by the reciprocal of the coefficient instead of multiplying when isolating the variable on one side of the equation, resulting in $m = -1$. The student needs to focus on understanding the arithmetic of solving equations.
	Option D is incorrect	The student likely distributed only to the first term in each set of parentheses, resulting in $\frac{2}{3}m-9=\frac{1}{3}m-27$. Next, the student likely subtracted $\frac{1}{3}m$ from both sides and added 9 to both sides of the equation to obtain $\frac{1}{3}m=-18$. Then the student likely divided by the reciprocal of the coefficient instead of multiplying when isolating the variable on one side of the equation, resulting in $m = -6$. The student needs to focus on

		understanding the arithmetic of solving equations.

Item Position	Rationale	
25	minimum, −4	To complete the statement about the quadratic function, the student could have first recognized that the vertex (highest or lowest point of the curve) of the graph is located at (−1, −4). The student also could have recognized that the graph is facing upward. The student then could have concluded that the function has a minimum value of −4. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
26	Option B is correct	To determine which system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]) can be used to determine the price in dollars of a hot dog, x, and the price in dollars of a bag of popcorn, y, the student should have written one equation that represents the amount each family paid in dollars to purchase hot dogs and bags of popcorn. The student should have set up the first equation as $2x + 3y = 8$ since the first family paid $8.00 for 2 hot dogs and 3 bags of popcorn. Next, the student should have set up the second equation as $5x + 4y = 16.5$ since the second family paid $16.50 for 5 hot dogs and 4 bags of popcorn.
	Option A is incorrect	The student likely switched the total amounts paid by the families. The student needs to focus on understanding how to write a system of equations from a verbal description.
	Option C is incorrect	The student likely grouped the hot dogs in the first equation, resulting in $2x + 5y = 8$, and grouped the bags of popcorn in the second equation, resulting in $3x + 4y = 16.5$. The student needs to focus on understanding how to write a system of equations from a verbal description.
	Option D is incorrect	The student likely switched the variables in both equations. The student needs to focus on understanding how to write a system of equations from a verbal description.

Item Position	Rationale	
27	Option C is correct	To determine which graph best represents an exponential function where the *y*-intercept is 2 and the function increases at a rate of 50%, the student first could have recognized that the graph would intersect (cross) the *y*-axis (vertical axis) at (0, 2) since the *y*-intercept is 2. Next, the student could have recognized that the function increases at a rate of 50%, so the common factor (constant rate by which successive value increase or decrease) is $b = 1 + 0.5 = 1.5$. Therefore, the student could have recognized that each *y*-value should be 1.5 times the previous *y*-value. Since (0, 2) represents the *y*-intercept, the value of *y* when $x = 1$ should be $y = 2(1.5) = 3$. Therefore, the student should have selected the graph that contains the points (0, 2) and (1, 3). This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student correctly used the common factor of 1.5 when graphing the function but likely used $y = 1$ instead of $y = 2$ as the *y*-intercept. The student needs to focus on understanding how to identify the graph of an exponential function given key features of the function.
	Option B is incorrect	The student likely used $y = 1$ as the *y*-intercept instead of $y = 2$. Then the student likely used 0.5 instead of 1.5 as the common factor when graphing the function, resulting in $y = 1(0.5) = 0.5$ when $x = 1$. The student needs to focus on understanding how to identify the graph of an exponential function given key features of the function
	Option D is incorrect	The student likely used 0.5 instead of 1.5 as the common factor when graphing the function, resulting in $y = 2(0.5) = 1$ when $x = 1$. The student needs to focus on understanding how to identify the graph of an exponential function given key features of the function.

Item Position	Rationale	
28	Option B is correct	To determine the equation in point-slope form [$y - y_1 = m(x - x_1)$, where m represents the slope of the line and (x_1, y_1) represents a point on the line] that best represents a line that passes through point W and is parallel to (does not intersect [cross] and is always the same distance from) line p, the student could have first chosen two points from the graph of line p to calculate the slope (steepness of a straight line when graphed on a coordinate grid, represented by $m = \frac{y_2 - y_1}{x_2 - x_1}$) of line p. The student could have substituted the points (−5, −2) and (5, 6) from the graph of line p into the slope formula, resulting in $m = \frac{6-(-2)}{5-(-5)} = \frac{4}{5}$. Since parallel lines have the same slope, the student should have concluded that the line passing through point W also has a slope of $\frac{4}{5}$. Next, the student could have substituted point $W(1, 5)$, and $m = \frac{4}{5}$ into $y - y_1 = m(x - x_1)$, resulting in $y - 5 = \frac{4}{5}(x - 1)$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely used the opposite value of the slope of line p, resulting in $m = -\frac{4}{5}$. The student needs to focus on understanding how to determine the slope of a line that is parallel to a given line.
	Option C is incorrect	The student likely used the slope of the line that is perpendicular to (intersects at a 90-degree angle) line p, resulting in $m = -\frac{5}{4}$. The student needs to focus on understanding how to determine the slope of a line that is parallel to a given line.
	Option D is incorrect	The student likely used the reciprocal of the slope of line p, resulting in $m = \frac{5}{4}$. The student needs to focus on understanding how to determine the slope of a line that is parallel to a given line.

Item Position	Rationale	
29	Option B is correct	To determine the coordinates of the vertex of the graph of *g*, the student could have identified $f(x) = x^2$ as the quadratic parent function and recognized that the coordinates of the vertex (highest or lowest point of the curve) of the graph of *f* are (0, 0). The student could have recognized that $f(x + 7.2)$ represents a graph whose vertex is shifted 7.2 units to the left of the graph of *f*. The student then could have concluded that the vertex of the graph of *g* is located 7.2 units to the left of (0, 0), at (−7.2, 0). This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely made a sign error when determining the vertex of the graph of *g*, resulting in (7.2, 0). The student needs to focus on understanding how changes to a function affect the graph of the function.
	Option C is incorrect	The student likely used a vertical translation rather than a horizontal translation and shifted the vertex of the graph of *f* 7.2 units up. The student needs to focus on understanding how changes to a function affect the graph of the function.
	Option D is incorrect	The student likely used a vertical translation rather than a horizontal translation and shifted the vertex of the graph of *f* 7.2 units down, resulting in (0, −7.2). The student needs to focus on understanding how changes to a function affect the graph of the function.

Item Position	Rationale	
30	decreases, 3,000	To complete the statement that describes the rate of change (constant rate of increase or decrease) of the altitude of the airplane with respect to time, the student could have chosen two ordered pairs from the table and calculated the change in the *y*-values and the *x*-values. The student could have used the ordered pairs (1.5, 25,500) and (3.25, 20,250) and applied the slope formula, $m = \frac{y_2 - y_1}{x_2 - x_1}$, resulting in $m = \frac{20{,}250 - 25{,}500}{3.25 - 1.5} = \frac{-5{,}250}{1.75} = -3{,}000$. Since the rate of change is negative, the altitude of the airplane is decreasing at a rate of 3,000 feet per minute. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
31	Option D is correct	To determine the solutions to the equation, the student could have used the square root method to solve the equation for the values of x. The student could have first divided both sides of the equation by 5, resulting in $(x + 3)^2 = 15$. Next, the student could have removed the square on the left side by taking the square root of both sides of the equation, resulting in $x + 3 = \pm\sqrt{15}$. Last, the student could have subtracted 3 from both sides of the equation, resulting in $x = -3 \pm \sqrt{15}$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely divided the 3 in the parentheses by 5 when trying to remove the 5 from the left side of the equation, resulting in $\left(x + \frac{3}{5}\right)^2 = 15$. Next, the student likely removed the square on the left side by taking the square root of both sides of the equation, resulting in $x + \frac{3}{5} = \pm\sqrt{15}$. Last, the student likely subtracted $\frac{3}{5}$ from both sides of the equation, resulting in $x = -\frac{3}{5} \pm \sqrt{15}$. The student needs to focus on understanding how to find solutions of quadratic equations using the square root method.
	Option B is incorrect	The student likely tried to remove the square on the left side of the equation by taking the square root of both sides of the equation but did not take the square root of the leading coefficient, 5, on the left side, resulting in $5(x + 3) = \pm 5\sqrt{3}$. The student then likely divided both sides of the equation by 5 but divided the 3 in the parentheses by 5 when trying to remove the 5 from the left side of equation, resulting in $x + \frac{3}{5} = \pm\sqrt{3}$. Last, the student likely subtracted $\frac{3}{5}$ from both sides of the equation, resulting in $x = -\frac{3}{5} \pm \sqrt{3}$. The student needs to

		focus on understanding how to find solutions of quadratic equations using the square root method.
	Option C is incorrect	The student likely tried to remove the square on the left side of the equation by taking the square root of both sides of the equation but did not take the square root of the leading coefficient, 5, on the left side, resulting in $5(x+3) = \pm 5\sqrt{3}$. The student then likely divided both sides of the equation by 5, resulting in $x + 3 = \pm\sqrt{3}$. Last, the student likely subtracted 3 from both sides of the equation, resulting in $x = -3 \pm \sqrt{3}$. The student needs to focus on understanding how to find solutions of quadratic equations using the square root method.

Item Position	Rationale	
32	Option D is correct	To determine the domain (all possible *x*-values) of the part of the quadratic function graphed on the grid, the student could have identified all the values of *x* for which the graph has a *y*-value. The student could have recognized that the graph contains a closed circle on the left at the point (−2, 5), meaning that the *x*-values of the graph start at and include the value $x = -2$. The student could have also recognized that the graph contains a closed circle on the right at the point (3, 0), meaning that the *x*-values of the graph end at and include the value $x = 3$. The student then could have recognized that every *x*-value between $x = -2$ and $x = 3$ produces a *y*-value. Therefore, the student could have concluded that the domain of the part of the function shown is the set of all real numbers greater than or equal to −2 and less than or equal to 3. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely identified the range (all possible *y*-values) of the part of the function graphed on the grid. The student needs to focus on understanding how to represent the domain of a quadratic function when given a part of the graph.
	Option B is incorrect	The student likely identified the domain as the part of the function between the *x*-intercepts (values where a graph crosses or touches the *x*-axis). The student needs to focus on understanding how to represent the domain of a quadratic function when given a part of the graph.
	Option C is incorrect	The student likely used all the *x*-values shown on the *x*-axis (horizontal number line) as the domain of the part of the function graphed on the grid. The student needs to focus on understanding how to represent the domain of a quadratic function when given a part of the graph.

Item Position	Rationale	
33	Option B is correct	To determine the equivalent expression, the student could have divided the coefficients and then applied the quotient of powers property $\left(\frac{a^m}{a^n} = a^{m-n}\right)$, resulting in $\frac{16}{4} \cdot k^{9-3} \cdot m^{7-14}$, or $4k^6m^{-7}$. The student could have then applied the negative exponent property $\left(a^{-n} = \frac{1}{a^n}\right)$ to m^{-7}, resulting in $\frac{4k^6}{m^7}$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely applied the quotient of powers property to the variables correctly but calculated the difference of the coefficients, resulting in $(16 - 4) \cdot k^{9 - 3} \cdot m^{7 - 14}$, or $\frac{12k^6}{m^7}$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.
	Option C is incorrect	The student likely calculated the difference between the coefficients and the quotients of the exponents, resulting in $(16 - 4) \cdot k^{9 \div 3} \cdot m^{7 \div 14}$, or $\frac{12k^3}{m^2}$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.
	Option D is incorrect	The student correctly divided the coefficients but calculated the quotients of the exponents, resulting in $4 \cdot k^{9 \div 3} \cdot m^{7 \div 14}$ or $4k^3m^{1/2}$. Then the student likely interpreted $m^{1/2}$ as $\frac{1}{m^2}$, resulting in $\frac{4k^3}{m^2}$. The student needs to focus on understanding how to use the properties of exponents to simplify expressions.

Item Position	**Rationale**	
34	(2*x* + 3), (*x* – 5) or (*x* – 5), (2*x* + 3)	To determine a possible equation for *h* in factored form, the student could have used the zeros (input values, *x*, that produce an output value, *y*, of zero) of the function to find the factors (numbers or expressions that can be multiplied to get another number or expression) of the function. The student could have recognized that $x = -\frac{3}{2}$ and *x* = 5 are zeros of the function since *h*(*x*) = 0 for both values of *x*. The student could have then rewritten each equation represented by the zeros of the function so that the right side is equal to zero. For $x = -\frac{3}{2}$, the student could have first multiplied both sides of the equation by 2, resulting in 2*x* = –3, and then added 3 to both sides of the equation, resulting in 2*x* + 3 = 0. For *x* = 5, the student could have subtracted 5 from both sides of the equation, resulting in *x* – 5 = 0. The student then could have concluded that (2*x* + 3) and (*x* – 5) are factors of the function; thus, *h*(*x*) = (2*x* + 3)(*x* – 5) is a possible equation. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
35	Option C is correct	To determine the perimeter of the triangle in units, the student could have added the side lengths, resulting in $\left(\frac{3}{2}x+\frac{5}{6}\right)+\left(2x+\frac{1}{3}\right)+\left(3x-\frac{1}{6}\right)$. Next, the student could have combined like terms (terms that contain the same variables raised to the same powers or constant terms), obtaining $\left(\frac{3}{2}+2+3\right)x+\left(\frac{5}{6}+\frac{1}{3}-\frac{1}{6}\right)=\frac{13}{2}x+1$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely added the coefficients and the constants, resulting in $\left(\frac{3}{2}+\frac{5}{6}+2+\frac{1}{3}+3-\frac{1}{6}\right)x=\frac{15}{2}x$. The student needs to focus on understanding how to combine like terms in polynomials.
	Option B is incorrect	The student likely added the coefficients and the constants and made a sign error, resulting in $\left(\frac{3}{2}+\frac{5}{6}+2+\frac{1}{3}+3+\frac{1}{6}\right)x=\frac{47}{6}x$. The student needs to focus on understanding how to combine like terms in polynomials.
	Option D is incorrect	The student likely made a sign error when combining the constant terms, so that the constant term in the perimeter became $\frac{5}{6}+\frac{1}{3}+\frac{1}{6}=\frac{4}{3}$. The student needs to focus on understanding how to combine like terms in polynomials.

Item Position	Rationale	
36	Option C is correct	To determine which linear equation represents the total cost in dollars, *y*, for *x* tickets, the student could have used the slope-intercept form of a linear equation ($y = mx + b$, where $m = \frac{y_2 - y_1}{x_2 - x_1}$ represents the slope of the line and *b* represents the value of the *y*-intercept). To determine the slope, the student could have found the rate of change (constant rate of increase or decrease) of the total cost in dollars with respect to the number of tickets purchased. The difference in the total cost in dollars is 300 – 160 = 140, and the difference in the number of tickets purchased is 8 – 4 = 4, so the rate of change is \$140 divided by 4, or \$35 per ticket purchased. Next, the student could have calculated the flat fee by substituting $m = 35$ and (4, 160) into $y = mx + b$ and solving for *b*, resulting in $160 = 35(4) + b$, or $20 = b$. Last, the student could have substituted $m = 35$ and $b = 20$ into the slope-intercept equation, resulting in $y = 35x + 20$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely interpreted the relationship as proportional and divided 160 by 4 to find the cost per ticket, resulting in $m = 40$. The student needs to focus on understanding how to write a linear function when given a description of a situation.
	Option B is incorrect	The student likely interpreted the relationship as proportional and divided 300 by 8 to find the cost per ticket, resulting in $m = 37.5$. The student needs to focus on understanding how to write a linear function when given a description of a situation.
	Option D is incorrect	The student likely switched the *m*- and *b*-values in $y = mx + b$, resulting in $y = 20x + 35$. The student needs to focus on understanding how to write a linear function when given a description of a situation.

Item Position	Rationale	
37	Option D is correct	To determine which expression is a factor of $x^2 + 7x - 30$, the student could have found the factors (numbers or expressions that can be multiplied to get another number or expression) of the expression. The student could have first determined that factors of x^2 are x and x and written x as the first term in each binomial factor. Next, the student could have determined that the second terms in the binomial factors are 10 and −3 because their product is −30 (the last term in the given expression) and their sum is 7 (the coefficient of the middle term in the given expression). The student could have then written the factors as $(x + 10)(x - 3)$. Finally, the student could have recognized that $(x - 3)$ is one of the factors of the given expression. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely determined that two factors of −30 are 15 and −2 but disregarded the value of the linear term of the expression, resulting in $(x + 15)(x - 2)$. The student needs to focus on understanding how to factor an expression of the form $x^2 + bx + c$.
	Option B is incorrect	The student likely made a sign error when factoring, resulting in $(x - 10)(x + 3)$. The student needs to focus on understanding how to factor an expression of the form $x^2 + bx + c$.
	Option C is incorrect	The student likely determined that two factors of −30 are 5 and −6 but disregarded the value of the linear term of the expression, resulting in $(x + 5)(x - 6)$. The student needs to focus on understanding how to factor an expression of the form $x^2 + bx + c$.

Item Position	Rationale	
38	less steep than, greater than	To complete the statement comparing the graphs of *f* and *g*, the student should have compared the slopes (steepness of a straight line when graphed on a coordinate grid, represented by $m = \frac{y_2 - y_1}{x_2 - x_1}$) and the *y*-intercepts (value where a graph crosses the *y*-axis) of the two graphs. The graph of function *g* has a slope of $\frac{1}{2}$, which is less than 1, the slope of the graph of function *f,* so the graph of function *g* is less steep than the graph of function *f*. The graph of function *g* has a *y*-intercept of 3, which is greater than 0, the *y*-intercept of the graph of function *f*. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
39	Option A is correct	To determine which system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]) represents line *n* and line *p*, the student could have used the graph and the table to find the two equations in slope-intercept form ($y = mx + b$, where $m = \frac{y_2 - y_1}{x_2 - x_1}$ represents the slope of the line and *b* represents the value of the *y*-intercept) and then converted each equation to standard form ($ax + by = c$ where *a*, *b*, and *c* are integers). To find the equation for line *n*, the student could have used the two points shown on the graph, (0, −2) and (1, 1), to determine the slope of line *n*, resulting in $m = \frac{1-(-2)}{1-0} = 3$. Next, the student could have recognized that the point (0, −2) on the graph represents the *y*-intercept, so $b = -2$. Since $m = 3$ and $b = -2$, the student could have written the equation of line *n* as $y = 3x - 2$. Last, the student could have subtracted *y* from both sides of the equation and added 2 to both sides of the equation to convert the equation from slope-intercept form to standard form, resulting in $3x - y = 2$. To find the equation for line *p*, the student could have used the first two points in the table, (−1, 6) and (0, 4), to determine the slope of line *p*, resulting in $m = \frac{4-6}{0-(-1)} = -2$. Next, the student could have recognized that the point (0, 4) from the table represents the *y*-intercept, so $b = 4$. Since $m = -2$ and $b = 4$, the student could have written the equation of line *n* as $y = -2x + 4$. Last, the student could have added $2x$ to both sides of the equation to convert the equation from slope-intercept form to standard form, resulting in $2x + y = 4$.

		This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely added $3x$ to the left side of the equation for line *n* when trying to convert the equation from slope-intercept form to standard form, resulting $3x + y = -2$. The student needs to focus on understanding how to write a linear function in standard form.
	Option C is incorrect	The student likely switched the coefficients of *x* and *y* for line *p* when trying to convert the equation from slope-intercept form to standard form, resulting in $x + 2y = 4$. The student needs to focus on understanding how to write a linear function in standard form.
	Option D is incorrect	The student likely added $3x$ to the left side of the equation for line *n* when trying to convert the equation from slope-intercept form to standard form, resulting $3x + y = -2$. Then the student likely switched the coefficients of *x* and *y* for line *p* when trying to convert the equation from slope-intercept form to standard form, resulting in $x + 2y = 4$. The student needs to focus on understanding how to write a linear function in standard form.

Item Position	Rationale	
40	Option C is correct	To determine which function is equivalent to $f(x) = 4(x - 3)^2 + 5$, the student could have first expanded the expression that is squared, resulting in $f(x) = 4(x - 3)(x - 3) + 5$. The student then could have multiplied each term in $(x - 3)$ by each term in $(x - 3)$, resulting in $f(x) = 4[x(x - 3) - 3(x - 3)] + 5$, $f(x) = 4(x^2 - 3x - 3x + 9) + 5$, and $f(x) = 4(x^2 - 6x + 9) + 5$. Next, the student could have multiplied each term in $(x^2 - 6x + 9)$ by 4, resulting in $f(x) = 4x^2 - 24x + 36 + 5$. Last, the student could have combined like terms (terms that contain the same variables raised to the same powers or constant terms), resulting in $f(x) = 4x^2 - 24x + 41$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely multiplied each term in $(x - 3)$ by 4 before expanding the group of terms that are squared, resulting in $f(x) = (4x - 12)^2 + 5$. The student needs to focus on understanding how to find the standard form of a quadratic function [$f(x) = ax^2 + bx + c$, where a, b, and c are real numbers] when given the vertex form.
	Option B is incorrect	The student likely squared each term in $(x - 3)$ instead of expanding the group of terms that are squared, resulting in $f(x) = 4(x^2 + 9) + 5$. The student needs to focus on understanding how to find the standard form of a quadratic function when given the vertex form.
	Option D is incorrect	The student likely multiplied each term in $(x - 3)$ by 4 before expanding the group of terms that are squared, resulting in $f(x) = (4x - 12)^2 + 5$. The student then likely doubled the 12 instead of squaring it, resulting in $f(x) = 16x^2 - 96x + 24 + 5$, or $f(x) = 16x^2 - 96x + 29$. The student needs to focus on understanding how to find the standard form of a quadratic function when given the vertex form.

Item Position	Rationale	
41	Option A is correct	To determine which graph best represents the solution set of the inequality $x + 2y \geq 2$, the student should have first recognized that the graph of the solution set would have a solid boundary line since the inequality symbol "≥" is used. Next, to graph the boundary line, the student could have found the *x*- and *y*-intercepts of the line. To find the *y*-intercept (value where a graph crosses the *y*-axis) of the line, the student could have substituted $x = 0$ into the equation and solved for *y*, resulting in $0 + 2y = 2$, $2y = 2$, and $y = 1$. Since the value of the *y*-intercept is 1, the line passes through the point (0, 1). To find the *x*-intercept (value where a graph crosses the *x*-axis) of the line, the student could have substituted $y = 0$ into the equation and solved for *x*, resulting in $x + 2(0) = 2$, or $x = 2$. Since the value of the *x*-intercept is 2, the line passes through the point (2, 0). Last, the student could have determined which half plane should be shaded by substituting (0, 0) into the inequality to test for a true statement. Since $0 + 2(0) \geq 2$ is a false statement, the ordered pair (0, 0) should not be included in the solution set. Therefore, the student should have selected the graph in which the half plane that does not contain the point (0, 0) is shaded. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student correctly identified the half plane containing the solution set but likely misinterpreted the inequality symbol "≥" as "greater than," which is represented by a dashed line. The student needs to focus on understanding how the inequality symbol affects the graph of the solution set of a linear inequality.
	Option C is incorrect	The student likely misinterpreted the inequality symbol "≥" as "less than or equal to" and selected the graph in which the half plane containing the solution set for $x + 2y \leq 2$ is

		shaded. The student needs to focus on understanding how the inequality symbol affects the graph of the solution set of a linear inequality.
	Option D is incorrect	The student likely misinterpreted the inequality symbol “≥” as “less than,” which is represented by a dashed line, and selected the graph in which the half plane containing the solution set for $x + 2y < 2$ is shaded. The student needs to focus on understanding how the inequality symbol affects the graph of the solution set of a linear inequality.

Item Position	Rationale	
42	Option D is correct	To determine which statement is true about the system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]), the student could have used the substitution method to try to solve the system of equations. The student could have substituted $y = 3x - 5$ into the equation $6x - 2y = 10$ and solved for x, resulting in $6x - 2(3x - 5) = 10$, or $6x - 6x + 10 = 10$. Next, the student could have combined like terms (terms that contain the same variables raised to the same powers or constant terms) on each side of the equation, resulting in $10 = 10$. Since the x terms were eliminated when like terms were combined, and the resulting equation yielded a true statement, the student could have concluded that the system has infinitely many solutions.
	Option A is incorrect	The student likely found a solution that yields a true statement for both equations but did not consider that other solutions were possible. The student needs to focus on understanding how to complete all the steps to calculate the solution to a system of equations.
	Option B is incorrect	The student likely found a solution that yields a true statement for both equations but did not consider that other solutions were possible. The student needs to focus on understanding how to complete all the steps to calculate the solution to a system of equations.
	Option C is incorrect	The student likely solved the system of equations correctly but interpreted the equation $10 = 10$ to mean that the system has no solutions since the x-terms were eliminated when the equations were solved. The student needs to focus on understanding how to complete all the steps to calculate the solution to a system of equations.

Item Position	Rationale	
43	$500(1.02)^x$ and any equivalent values are correct	To write the exponential function that models the number of employees in a company, y, after x years, the student could have used the form $y = ab^x$, where a is the initial value (starting value), b is the common factor (constant rate by which successive values increase or decrease), and x is the variable (symbol used to represent an unknown number). From the given information, the student could have determined that the initial number of employees in the company is 500, so $a = 500$. Next, the student could have recognized that since the number of employees in the company is expected to grow at a rate of 2% each year, this situation represents exponential growth with a growth factor of $b = 1 + 0.02$, or $b = 1.02$. Substituting $a = 500$ and $b = 1.02$ into the exponential function $y = ab^x$, the student could have obtained $y = 500(1.02)^x$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
44	Option C is correct	To determine which relation (relationship between the *x*- and *y*-values of ordered pairs) best represents *y* as a function of *x*, the student could have recalled that a function is a relation where each input, *x*, has a single output, *y*. The student could have analyzed the table and noticed that each value of *x* has only one corresponding value of *y*. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely misunderstood the definition of a function and selected the relation where each output, *y*, has a single input, *x*. The student needs to focus on understanding whether a relation represented in a table defines a function.
	Option B is incorrect	The student likely concluded that any graph that is symmetrical about the *x*-axis (horizontal number line) represents a function. The student needs to focus on understanding whether a relation represented in a graph is a function.
	Option D is incorrect	The student likely concluded that any graph that is symmetrical about the *x*-axis and the *y*-axis (vertical number line) represents a function. The student needs to focus on understanding whether a relation represented in a graph is a function.

Item Position	Rationale	
45	Option B is correct	To determine which statement is true about the solution to the system of equations (two or more equations containing the same set of variables [symbols used to represent unknown numbers]), the student should have recognized that, since the second equation in the system has a different slope (steepness of a straight line when graphed on a coordinate grid, represented by $m = \frac{y_2 - y_1}{x_2 - x_1}$) than the first equation, the lines must intersect (cross) when graphed. Since the lines intersect when graphed, the system has exactly one solution.
	Option A is incorrect	The student likely misinterpreted the different slopes to mean that the system has no solutions. The student needs to focus on understanding how to interpret the solution to a system of equations.
	Option C is incorrect	The student likely correctly determined that the lines must intersect but misinterpreted the *x*- and *y*-coordinates of the intersection point as two different solutions to the system. The student needs to focus on understanding how to interpret the solution to a system of equations.
	Option D is incorrect	The student likely misinterpreted the different slopes to mean that the system has infinitely many solutions since each line contains an infinite set of points. The student needs to focus on understanding how to interpret the solution to a system of equations.

Item Position	Rationale	
46	Option D is correct	To determine the solution to the equation $7w - 2(w - 9) = 4 - 8(w + 2)$, the student could have first distributed (multiplied) the numbers in front of the parentheses to each term inside the parentheses, resulting in $7w - 2w + 18 = 4 - 8w - 16$. Next, the student could have combined like terms (terms that contain the same variables raised to the same powers or constant terms) on each side of the equation, resulting in $5w + 18 = -8w - 12$. Then the student could have added $8w$ to both sides and subtracted 18 from both sides of the equation, resulting in $13w = -30$. Last, the student could have divided both sides of the equation by 13, resulting in $w = -\frac{30}{13}$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option A is incorrect	The student likely subtracted 8 from 4 before distributing, resulting in $7w - 2(w - 9) = -4(w + 2)$. Next, the student likely distributed the number in front of each set of parentheses to each term inside the parentheses, resulting in $7w - 2w + 18 = -4w - 8$. Then the student likely combined like terms on each side of the equation, resulting in $5w + 18 = -4w - 8$. Then the student likely added $4w$ to both sides and subtracted 18 from both sides of the equation, resulting in $9w = -26$. Last, the student likely divided both sides of the equation by 9, resulting in $w = -\frac{26}{9}$. The student needs to focus on understanding the arithmetic of solving equations.
	Option B is incorrect	The student likely subtracted 8 from 4 before distributing, resulting in $7w - 2(w - 9) = -4(w + 2)$. Next, the student likely distributed the number in front of each set of parentheses to each term inside the parentheses but made a sign error on the second term in the second set of parentheses, resulting in $7w - 2w + 18 = -4w + 8$. Then the student likely combined like

		terms on each side of the equation, resulting in $5w + 18 = -4w + 8$. Then the student likely added $4w$ to both sides and subtracted 18 from both sides of the equation, resulting in $9w = -10$. Last, the student likely divided both sides of the equation by 9, resulting in $w = -\frac{10}{9}$. The student needs to focus on understanding the arithmetic of solving equations.
	Option C is incorrect	The student likely distributed only to the first term in each set of parentheses, resulting in $7w - 2w - 9 = 4 - 8w + 2$. Then the student likely combined like terms on each side of the equation, resulting in $5w - 9 = 6 - 8w$. Next, the student likely added $8w$ and 9 to both sides of the equation, resulting in $13w = 15$. Last, the student likely divided both sides of the equation by 13, resulting in $w = \frac{15}{13}$. The student needs to focus on understanding the arithmetic of solving equations.

Item Position	Rationale	
47	$2x + 9$, $2x - 9$ or $2x - 9$, $2x + 9$	To determine which two factors can be used to create an expression equivalent to $4x^2 - 81$, the student could have recognized that the expression represents a difference of two squares and applied the rule for the difference of two squares: $a^2 - b^2 = (a + b)(a - b)$. The student could have recognized that $4x^2$ is equivalent to $(2x)^2$ and that 81 is equivalent to 9^2. Therefore, applying the rule for the difference of squares results in $4x^2 - 81 = (2x + 9)(2x - 9)$. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.

Item Position	Rationale	
48	Option C is correct	To determine the value of $f(4)$, the student should have substituted 4 for x in the function (relationship where each input value has a single output value) and then simplified the function, resulting in $f(4) = 3(4)^2 - 7 = 3(16) - 7 = 48 - 7 = 41$.
	Option A is incorrect	The student likely squared the 3 instead of squaring the 4, resulting in $f(4) = 3^2(4) - 7 = 9(4) - 7 = 36 - 7 = 29$. The student needs to focus on understanding how to apply the order of operations when simplifying a numerical expression.
	Option B is incorrect	The student likely multiplied by 2 instead of squaring the 4, resulting in $f(4) = 3(4)(2) - 7 = 24 - 7 = 17$. The student needs to focus on understanding how to apply the order of operations when simplifying a numerical expression.
	Option D is incorrect	The student likely subtracted 7 before multiplying by 3, resulting in $f(4) = 3(4^2 - 7) = 3(16 - 7) = 3(9) = 27$. The student needs to focus on understanding how to apply the order of operations when simplifying a numerical expression.

Item Position	Rationale	
49	Option B is correct	To determine the domain (all possible x-values) of the function for the situation, the student should have identified all the values of x for which the graph has a y-value. The graph extends from $x = 0$ at its lowest point to $x = 12$ at its highest point and includes all x-values between $x = 0$ and $x = 12$. Therefore, the student should have concluded that the domain of the function is represented by the inequality $0 \le x \le 12$.
	Option A is incorrect	The student likely used the values shown on the x-axis (horizontal number line) of the graph as the domain for the situation, resulting in $0 \le x \le 14$. The student needs to focus on understanding how to represent the domain of a linear function when given a part of the graph.
	Option C is incorrect	The student likely used the values shown on the y-axis (vertical number line) of the graph as the domain for the situation, resulting in $0 \le y \le 110$. The student needs to focus on understanding how to represent the domain of a linear function when given a part of the graph.
	Option D is incorrect	The student likely identified the range (all possible y-values) of the function for the situation, resulting in $0 \le y \le 100$, instead of identifying the domain. The student needs to focus on understanding how to represent the domain of a linear function when given a part of the graph.

Item Position	Rationale	
50	Option A is correct	To determine the value that represents the *y*-intercept of the line, the student could have found *y*-value of the point where the graph intersects (crosses) the *y*-axis (vertical number line). Since the graph intersects the *y*-axis at the point (0, −2), the student could have concluded that the value of the *y*-intercept of the line is −2. This is an efficient way to solve the problem; however, other methods could be used to solve the problem correctly.
	Option B is incorrect	The student likely found both the *x*-intercept and the *y*-intercept but divided the value of the *x*-intercept by the value of the *y*-intercept. The student needs to focus on understanding how to identify the intercepts of a linear function when given a graph.
	Option C is incorrect	The student likely found the slope (steepness of a straight line when graphed on a coordinate grid, represented by $m = \frac{y_2 - y_1}{x_2 - x_1}$) of the line. The student needs to focus on understanding how to identify the intercepts of a linear function when given a graph.
	Option D is incorrect	The student likely found the *x*-intercept, the *x*-value of the point where the graph intersects the *x*-axis (horizontal number line). The student needs to focus on understanding how to identify the intercepts of a linear function when given a graph.